EuropeAid

Commission of the European Communities
Brussels

on behalf of

Armenian Government - Ministry of Energy

GARGAR
Small Hydropower Project

Feasibility Study Annex

EUROPEAID/112946/C/SV/AM

December 2004

FICHTNER Consulting Engineers
Stuttgart/Germany

YSUAC - Yerevan State University
of Architecture and Construction

December 2004

Gargar SHPP

Feasibility Study

Annex

FICHTNER / YUASC

5761A25-000/12672434

December 2004

Gargar SHPP

Feasibility Study

Annex 3

FICHTNER/ YUASC

5761A25-000/12672434

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Environmental Impact Assessment

Table of Content

Table: Environmental Mitigation Costs

GARGAR HPP Penstock

Mitigation measures

Afforestation Costs

Structure	Species	Unit Cost USD	No. of Trees	Total Cost USD
Headwork (head construction)	Planting of trees	0	0	0
Turbine waterway (penstock)	Planting of trees	0	0	0
Power house area	Planting of trees	0	0	0
Access road to the headworks	Planting of trees	0	0	0
Access road to the shaft	Planting of trees	0	0	0
Total				**0**

Permanent Land Required for Hydropower Station

Structure	Private		State		Total		
	Land m2	Unit Cost AMD	Land	Unit Cost AMD	Land	Unit Cost AMD	Cost USD
Headwork (head construction)	21000	2500		222	21000	2500	93,750.00
Turbine waterway (penstock)		2500	97000	222	97000	222	38,453.57
Power house area		2500	3000	222	3000	222	1,189.29
Total							**133,392.86**

Temporary Land Required for Hydropower Station

Structure	Private		State		Total		
	Land	Unit Cost AMD	Land	Unit Cost AMD	Land	Unit Cost AMD	Cost USD
Headwork (head construction)							
Turbine waterway (penstock)							
Power house area							
Access road to the shaft							
Total					**0**	**0**	**0**

* Costs for renting and bying of land is taken according to the Cadastre prices (5-th region) and product on 1,25 K (currency rate fluctuation and prices rising risks)
Based on the RA Government Resolution N 1746-N dated 24/12/2003 Region for required land is XIV. And the Coefficient for Cadastral price is equal to 0,0037

According to the same resolution the Regoin for required land in Stepanavan is XIII. And the Coefficient for Cadastral price is equal to 0,0057

The Cadastral price is calculated asfollows: 60,000 AMD (Based on Cadastre Price on 1 sq.m x 0,0057 K) for Stepanavan = 342 AMD, and (1 sq.m x 0,0037 for other area) = 222 AMD

The Prices for Private Sector are taken on the basis of market prices in the region: 1 sq.m = 2500 AMD

Ecology Map

ECOLOGY MAP

Sc 1: 25000

N

Wildlife

Animals extractive by licence:

- Hare
- Fox
- Wolf
- Cabane
- Squrell

Animals and birds included in the Red Book:

Animals:

- Leopard
- Forest cat
- Bear
- Roe
- Carnivore
- Snake

Birds:

- Many-coloured thrush
- Rock thrush
- Woodpecker
- Sparrow (fly-catching)
- Falcon (hawk)
- Sparrow (white-throat)
- Sparrow (nuthatch)

Cultural monuments:

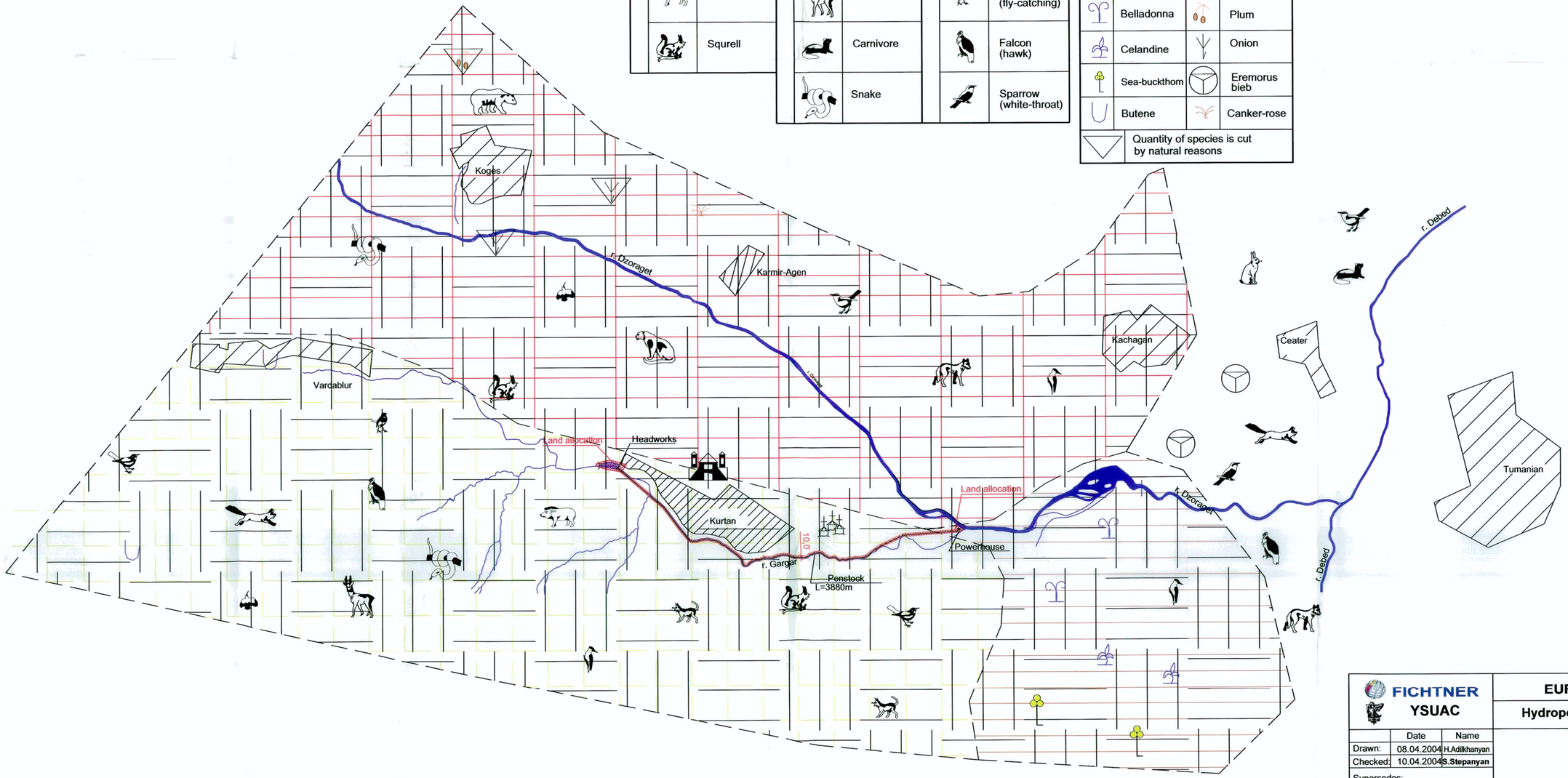
- Church
- Complexes of conventual buildings

Flora:

- Belladonna
- Celandine
- Sea-buckthorn
- Butene
- Plum
- Onion
- Eremorus bieb
- Canker-rose
- Quantity of species is cut by natural reasons

Acres:

- Forest vegetation
- Agricultural lands instead of deciduous beech and oak and hornbeam forests
- Steppe vegetation
- Grain, grain and motley grass steppes
- Agricultural lands instead of steppes
- Typical black earth



FICHTNER YSUAC	EUROPEAN COMMISSION		EuropeAid
	Hydropower Development in Armenia		
	Date	Name	Feasibility Study
Drawn:	08.04.2004	H.Adilkhanyan	GARGAR SHPP
Checked:	10.04.2004	S.Stepanyan	ECOLOGY MAP
Supersedes:			Scale: 1 : 25000
Superseded by:	Size: 650x420	Project No.: 5761A25	Document No: 12672374
System: AutoCAD 2004	Annex: 1	Drawing No.:	BW13A001
			Sheet: 1 of 1

GARGAR SHPP

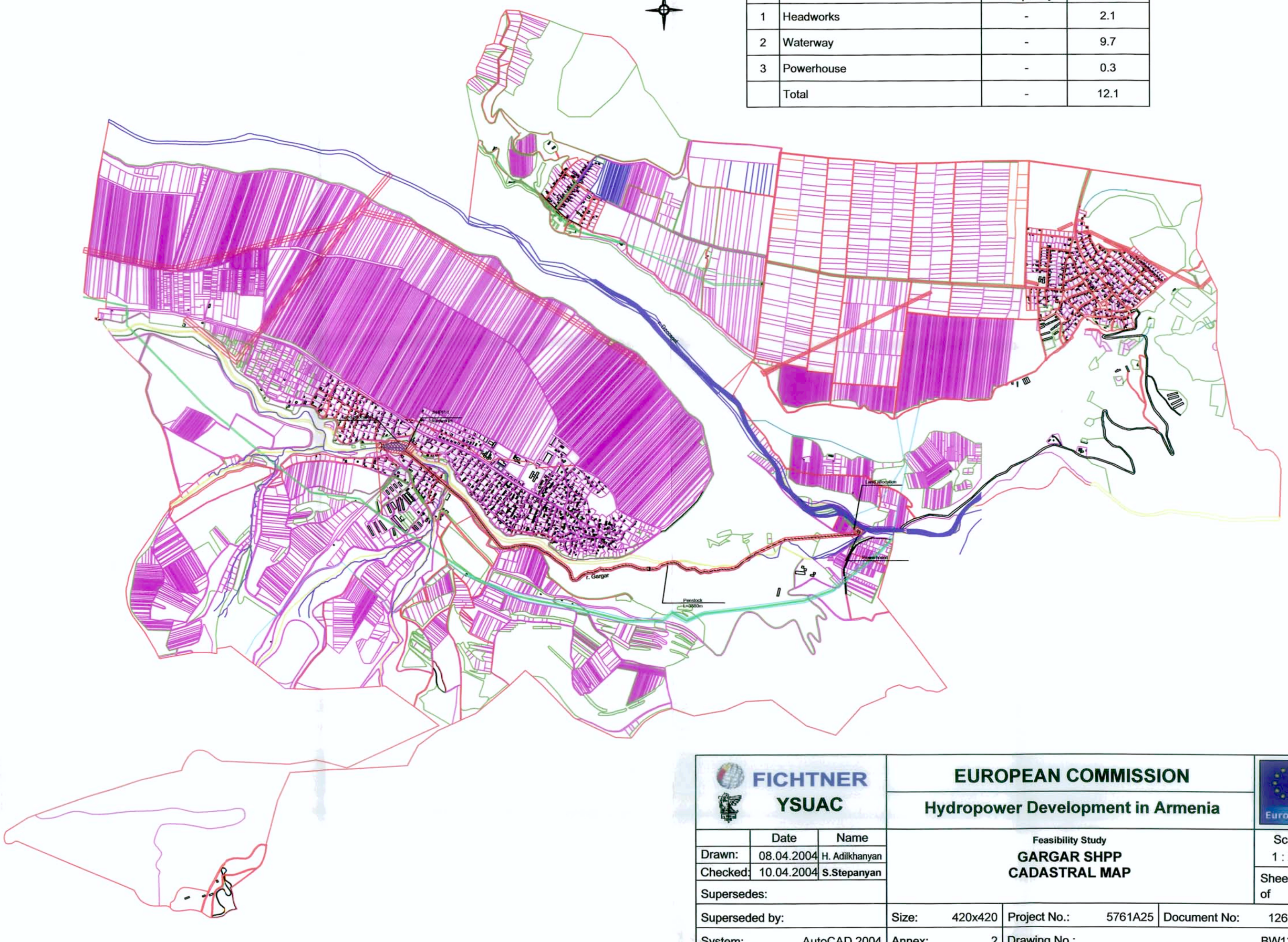
Plan

Sc 1:25000

N

Table of land allocation for Gargar SHPP

N	Construction	Gargar SHPP	
		Area, hectare	
		Temporary	Permanent
1	Headworks	-	2.1
2	Waterway	-	9.7
3	Powerhouse	-	0.3
	Total	-	12.1



FICHTNER
YSUAC

EUROPEAN COMMISSION

Hydropower Development in Armenia

EuropeAid

	Date	Name
Drawn:	08.04.2004	H. Adilkhanyan
Checked:	10.04.2004	S.Stepanyan
Supersedes:		
Superseded by:		
System:	AutoCAD 2004	

Feasibility Study

GARGAR SHPP
CADASTRAL MAP

Scale: 1 : 25000

Sheet: 1 of 1

Size:	420x420	Project No.:	5761A25	Document No:	12672421
Annex:	2	Drawing No.:			BW13A002

Land Allocation Map

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Data Basis

4.2

Topography and Surveying

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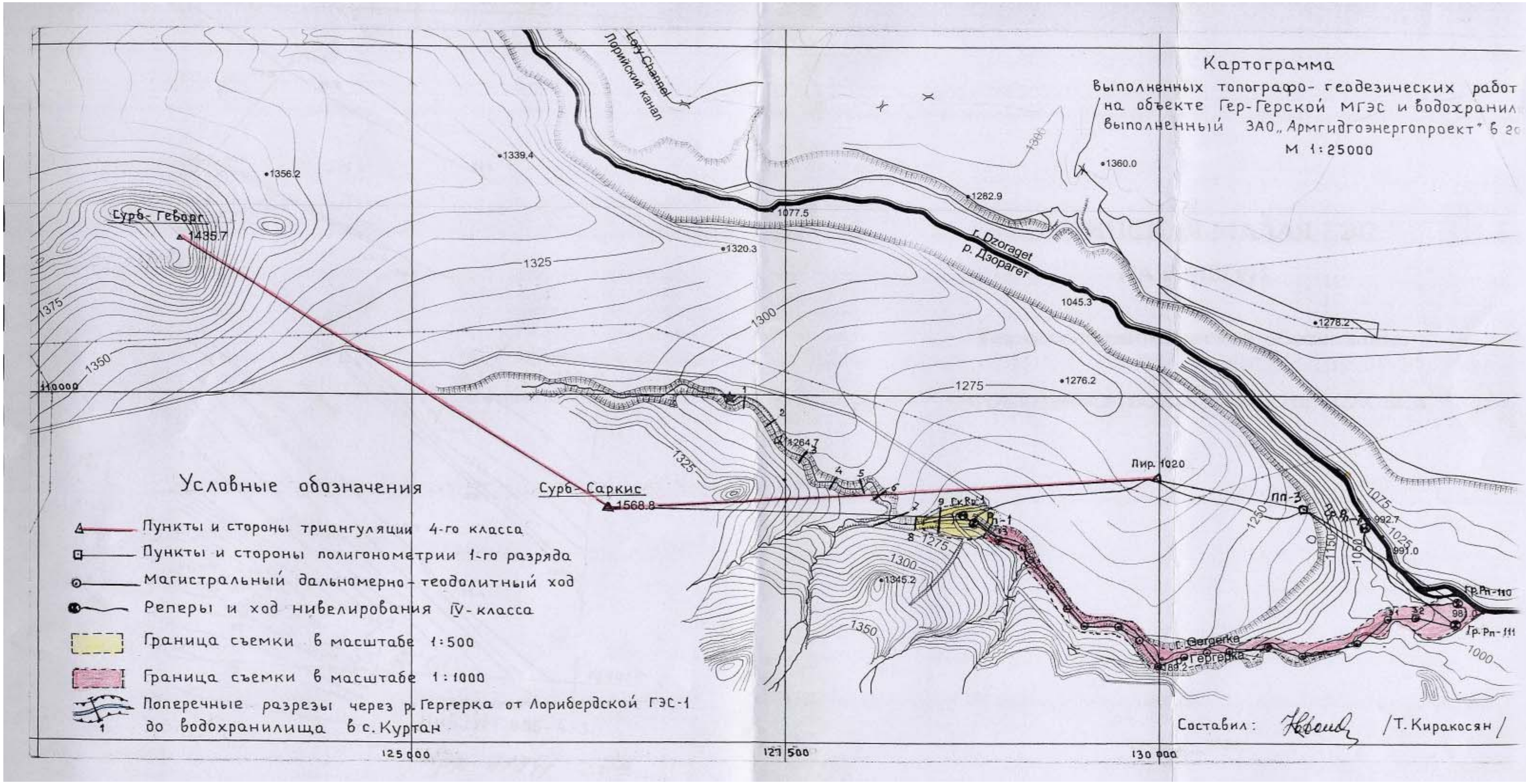
Sketch of Carried out Works
Location of Benchmarks


Картограмма
выполненных топографо- геодезических работ
на объекте Гер-Герской МГЭС и водохранил
выполненный ЗАО „Армгидроэнергопроект" в го
М 1:25000
Lory Channel
Лорийский канал
r. Dzoraget
р. Дзорагет
Сурб-Геворг
1435.7
Сурб-Саркис
1568.8
Пир. 1020
r. Gergerka
р. Гергерка
Гр. Рп-110
Гр. Рп-111
Условные обозначения
Пункты и стороны триангуляции 4-го класса
Пункты и стороны полигонометрии 1-го разряда
Магистральный дальномерно-теодолитный ход
Реперы и ход нивелирования IV-класса
Граница съемки в масштабе 1:500
Граница съемки в масштабе 1:1000
Поперечные разрезы через р. Гергерка от Лорибердской ГЭС-1 до водохранилища в с. Куртан
Составил: /Т. Киракосян/
125 000
127 500
130 000
110000

Description of Relevant Benchmarks in the Field

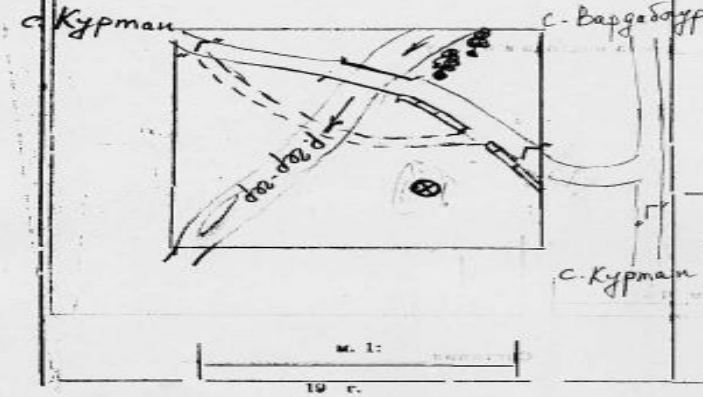
Т-11
1964 г.

Триангуляция
Нивелирование
класса Скалькой репер-1 Гер-герский МГЭС

Трапеция

Описание местоположения пункта

Ск. Рп-1 расположен внутри каменного ограждения трансформаторной подстанции, на левом берегу р. Гергер ниже моста на расстоянии 50 м.



м. 1:

19 г.

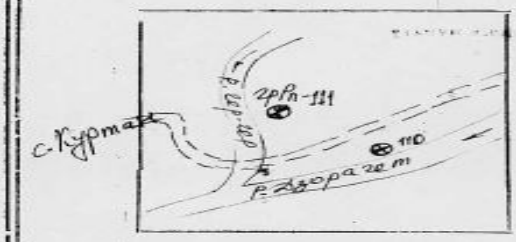
Т-11
1964 г.

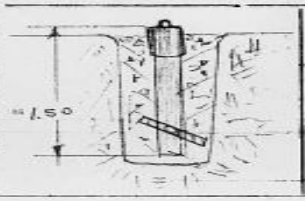
Триангуляция
Нивелирование
класса ГрРр-110, ГрРр-111 Гер-герский МГЭС

Трапеция

Описание местоположения пункта

Гр Рп-110 и 111 расположены в районе слияния рек Дзорагет и Гергер. Гр Рп 110 заложен на правом берегу р. Дзорагет на расстоянии 40 м от слияния рек, а Гр Рп 111 заложен на левом берегу р. Гергер на расстоянии 8 м расстояние между реперами 64





м. 1:

19 г.

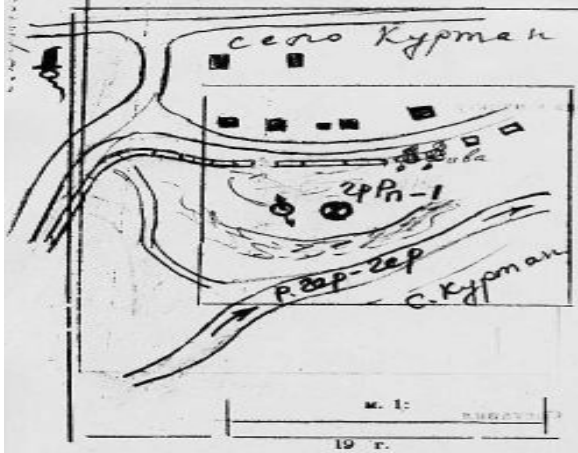
Т-11
1964 г.

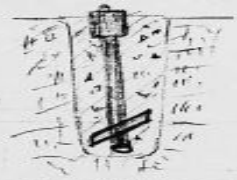
Триангуляция
Нивелирование
класса Гр Репер – 1 Гер-герский МТЭС

Трапеция

Описание местоположения пункта

Гр Рп-1 расположен в селе Курман на левом берегу р. Гергер ниже моста на расстоянии 250 м в районе сельбора проектируемого водохранилища у опоры ЛЭП – 60 кВ.



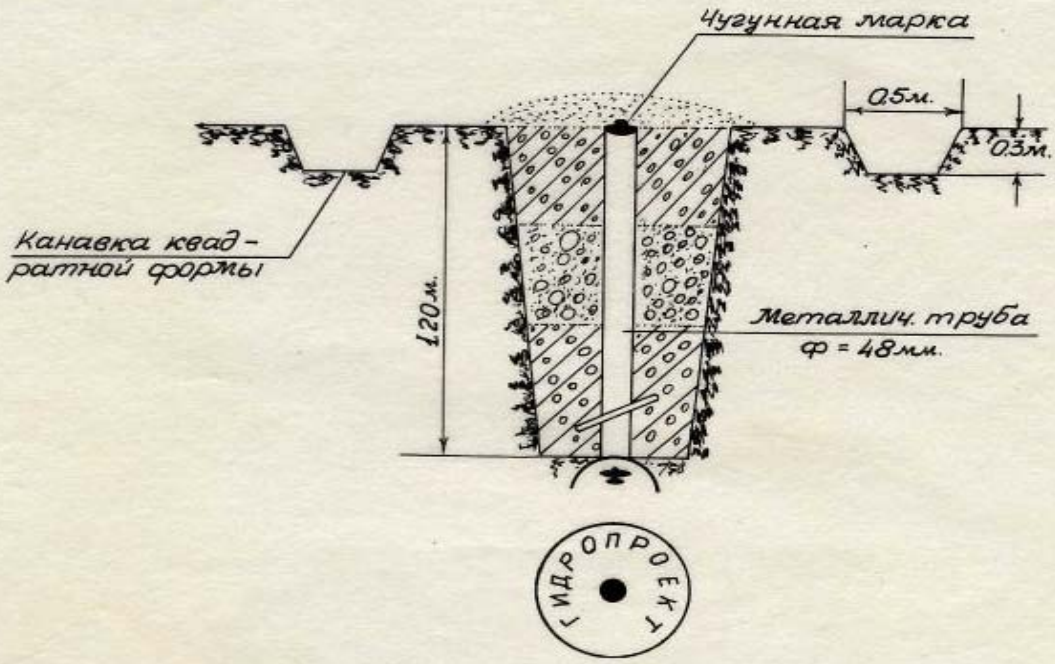


м. 1:

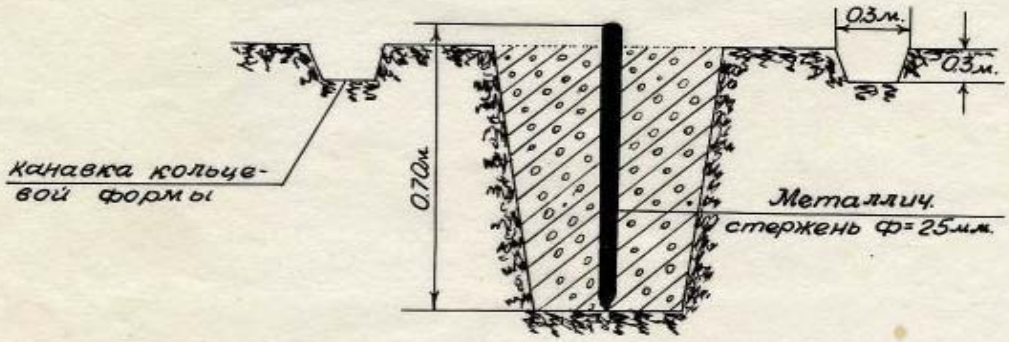
19 г.

Drawings of Benchmarks

Разрез центра полигонометрии 1 разряда



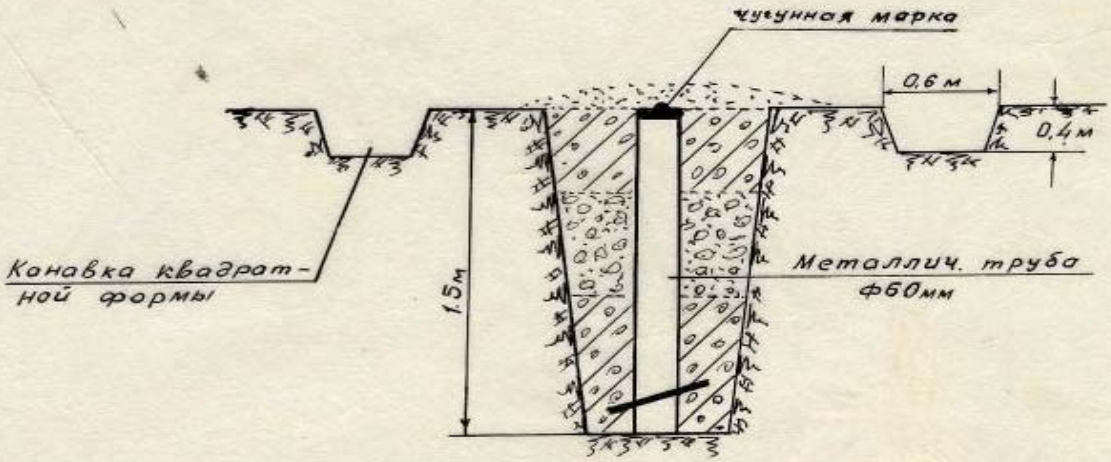
Разрез центра полигонометрии 2 разряда



Нач. топогеод. партии №2 /Петросян П.А./

Составил: /Хачатрян С.С./

Разрез грунтового репера нивелирования III класса

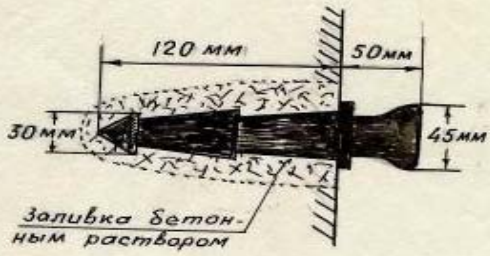


ГИДРОПРОЕКТ

Разрез скальной марки

ГИДРОПРОЕКТ

Разрез стенной марки



ГИДРОПРОЕКТ

Нач. топогеодез. партии №2 /Гичян П.А./

Составил: ст. топограф /Аветисян М.А./

Coordinates and Elevations of Benchmarks

Table: Coordinates and Elevations of Benchmarks

Local Coordinate Sytem
Baltic Elevation System

№	Points designation	Coordinates		Absolute elevation
		X (m)	Y (m)	Нм m ASL
1	Saint. Sargis	109189:100	126296.71	
2	ГрRn-1	109141.751	12875645	1250419
3	Dn 10	109239.575	128772112	
4	Dn 11	109148.85	12857941	1251677
5	Dn 12	109049.17	128688.92	1252840
6	Dn 13	10902064	128834.66	124140
7	Tx-14	108955.74	129028.68	123876
8	Tx-15	108811.91	128115.81	123708
9	Tx-16	108680.86	129246.85	1234.01
10	Tx-17	108549.29	129326.22	122846
11	Tx-18	108395.07	129447.63	122572
12	Tx-19	108415.42	129646.97	121745
13	Tx-20	108397.02	129714.20	121566
14	Tx-21	10837024	129760.67	121331
15	Tx-22	108232.31	129899.00	121229
16	Tx-23	108133.90	130043.70	120345
17	Tx-24	108136.86	13011939	119667
18	Tx-25	108145.55	130206.24	118515
19	Tx-26	108147.76	130368.96	115708
20	Tx-27	108185.63	130472.73	113240
21	Tx-28	108199.00	130659.87	112065
22	Tx-29	108088.67	130950.50	114559
23	Tx-30	108206.78	131403.97	106607
24	Tx-31	108204.34	131636.54	104375
25	Tx-32	108432.67	131660.22	101785
26	GpRp 110	108486.64	132047.93	98325
27	GpRp 111	108428.91	13203141	98515
28	CKRp1			1248.060

Table: Coordinates and Elevations of Cross Sections Through Gargar River Gorge

Local Coordinate Sytem
Baltic Elevation System

№	Points designation	Coordinates		Absolute elevation
		X (m)	Y (m)	Нм m ASL
1	**2**	**3**	**4**	**5**
1	non-1	109934.39	127087.66	1273.83
2	non-2	109942.67	127246.44	1271.61
3	non-3	109761.76	127408.67	1268.09
4	non-4	109560.06	127595.57	1263.23
5	non-5	109385.15	127694.60	1261.48
6	non-6	109330.40	127938.53	1258.34
7	non-7	109262.30	128114.49	1255.21
8	non-8	109108.03	128195.65	1251.69
9	non-9	109120.60	128529.60	1246.60

4.3

Hydrology

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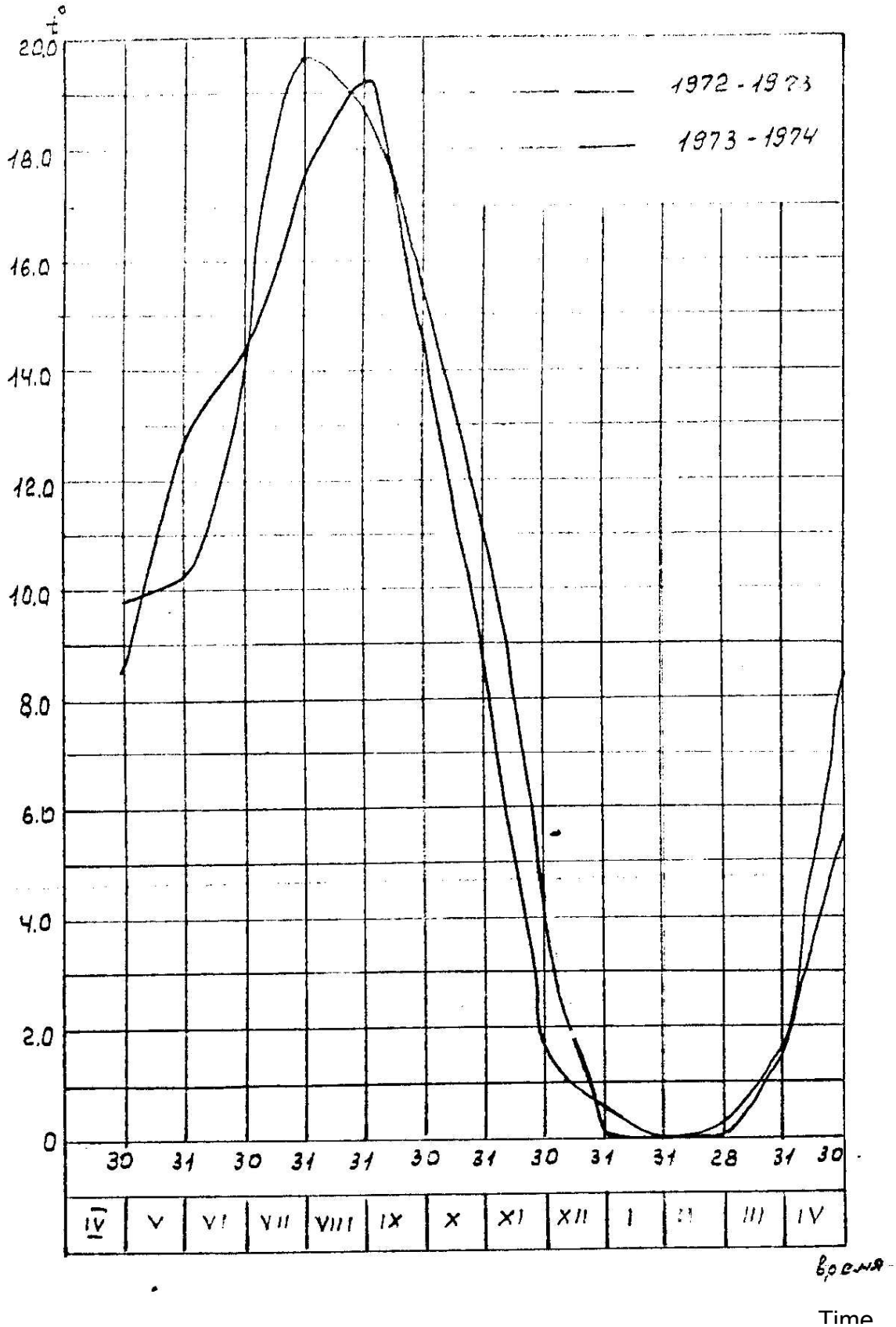


Figure: Average monthly water temperature of Gargar River at Gauge Kurtan

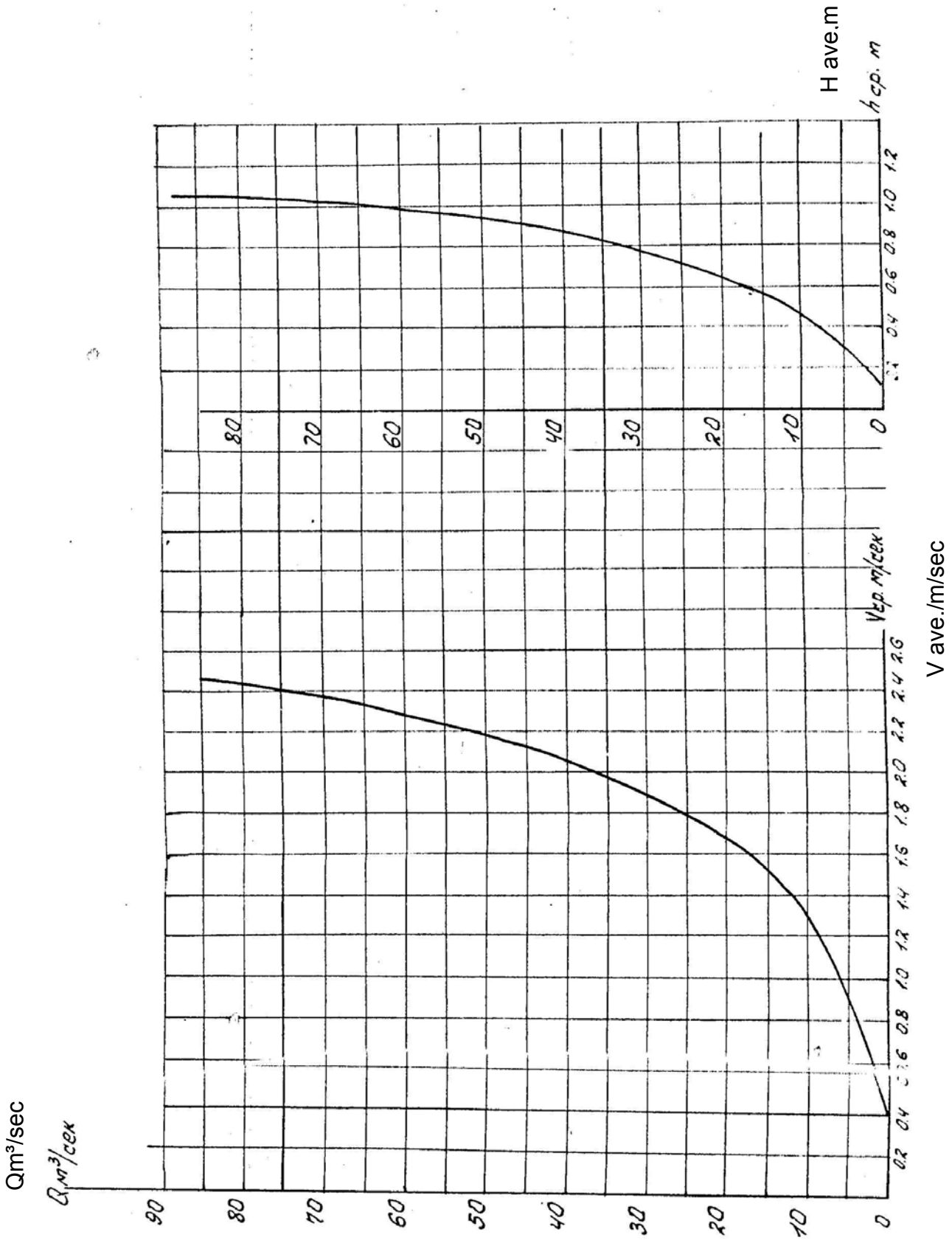


Figure: Graphs Q=f(h) and Q=f(v) at Gargar River - Kurtan

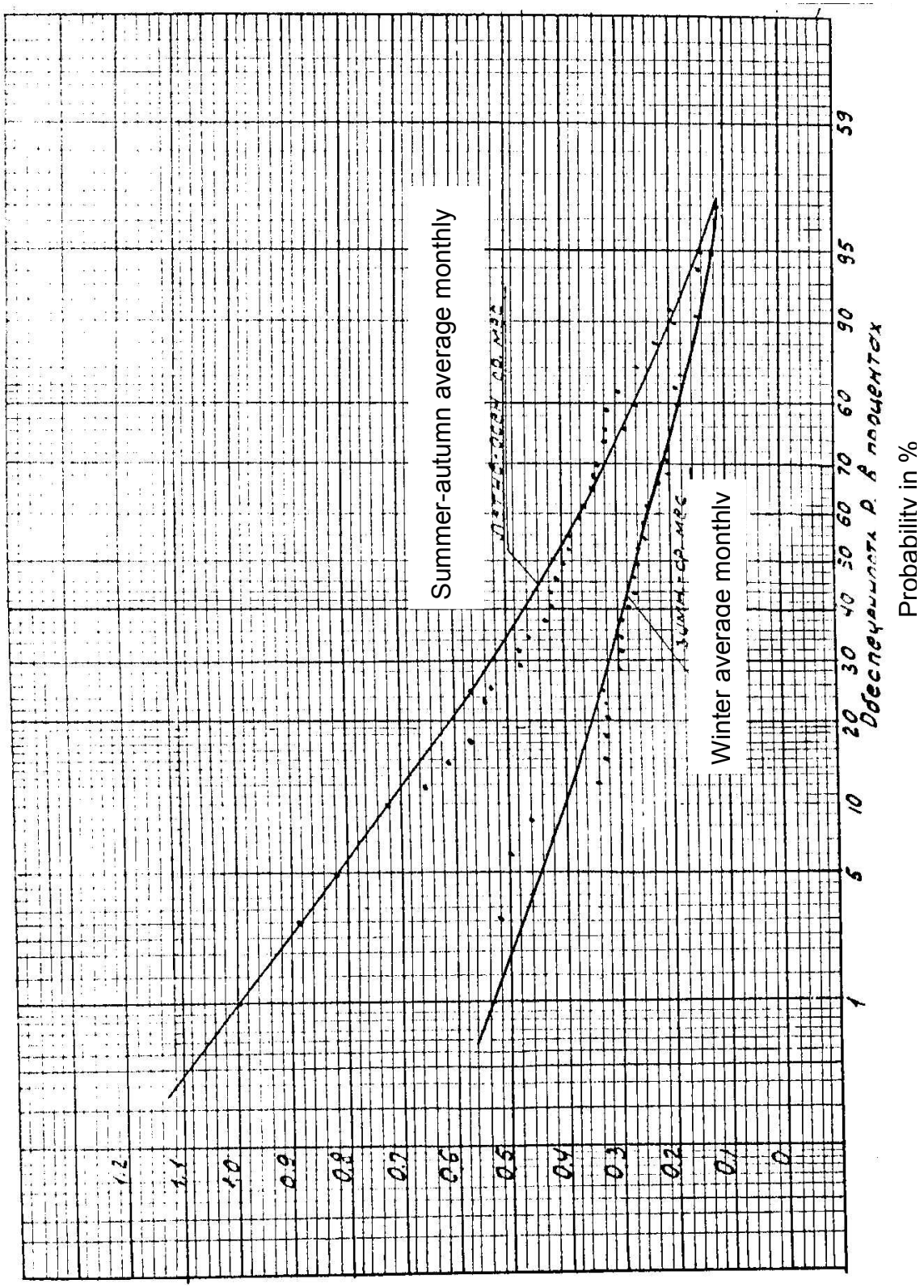


Figure: Probability curves of minimum flow of Gargar River – Kurtan Summer-Autumn Average Monthly and Winter Average Monthly

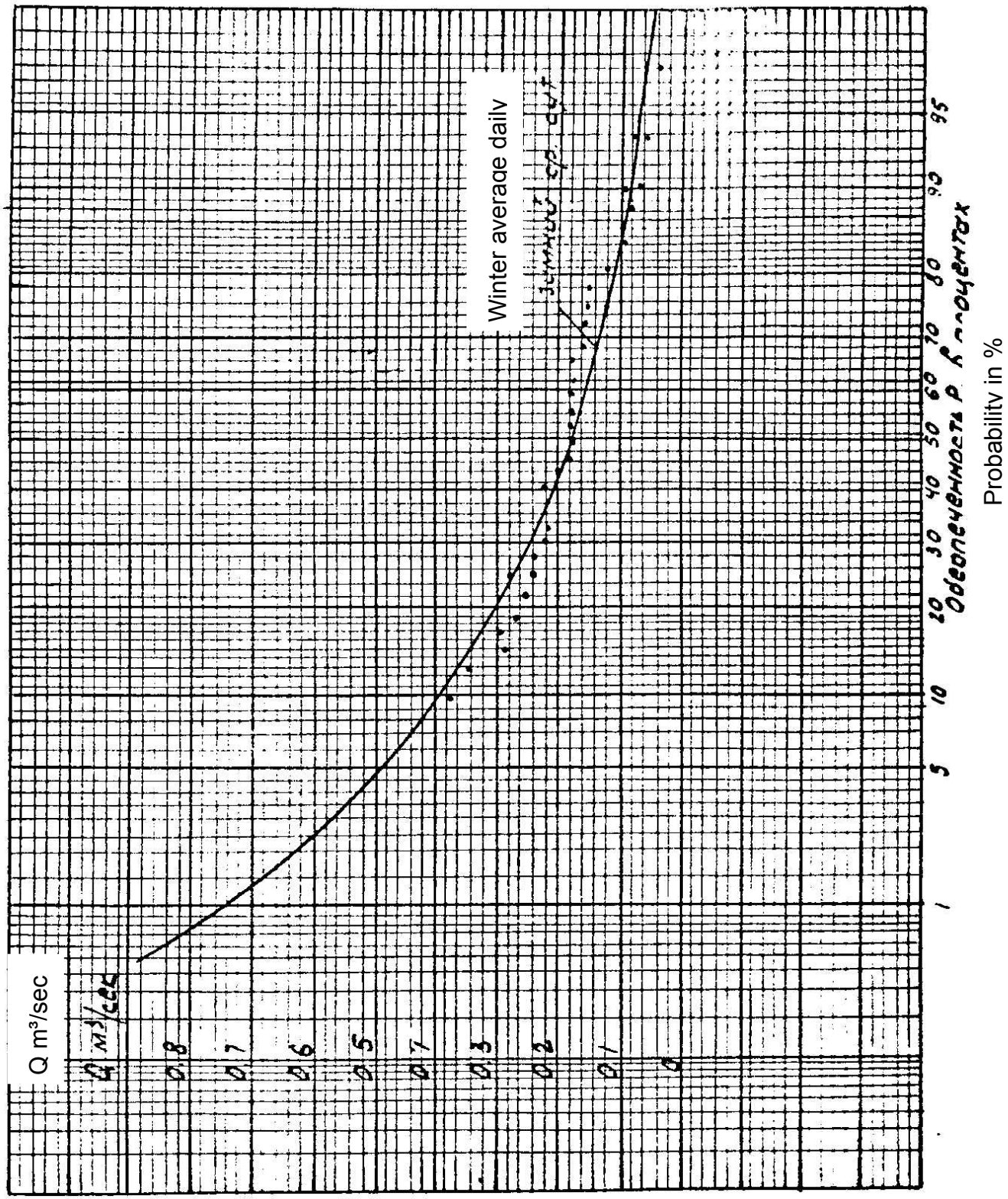


Figure: Probability curves of minimum flow of Gargar River-Kurtan Winter Average Daily

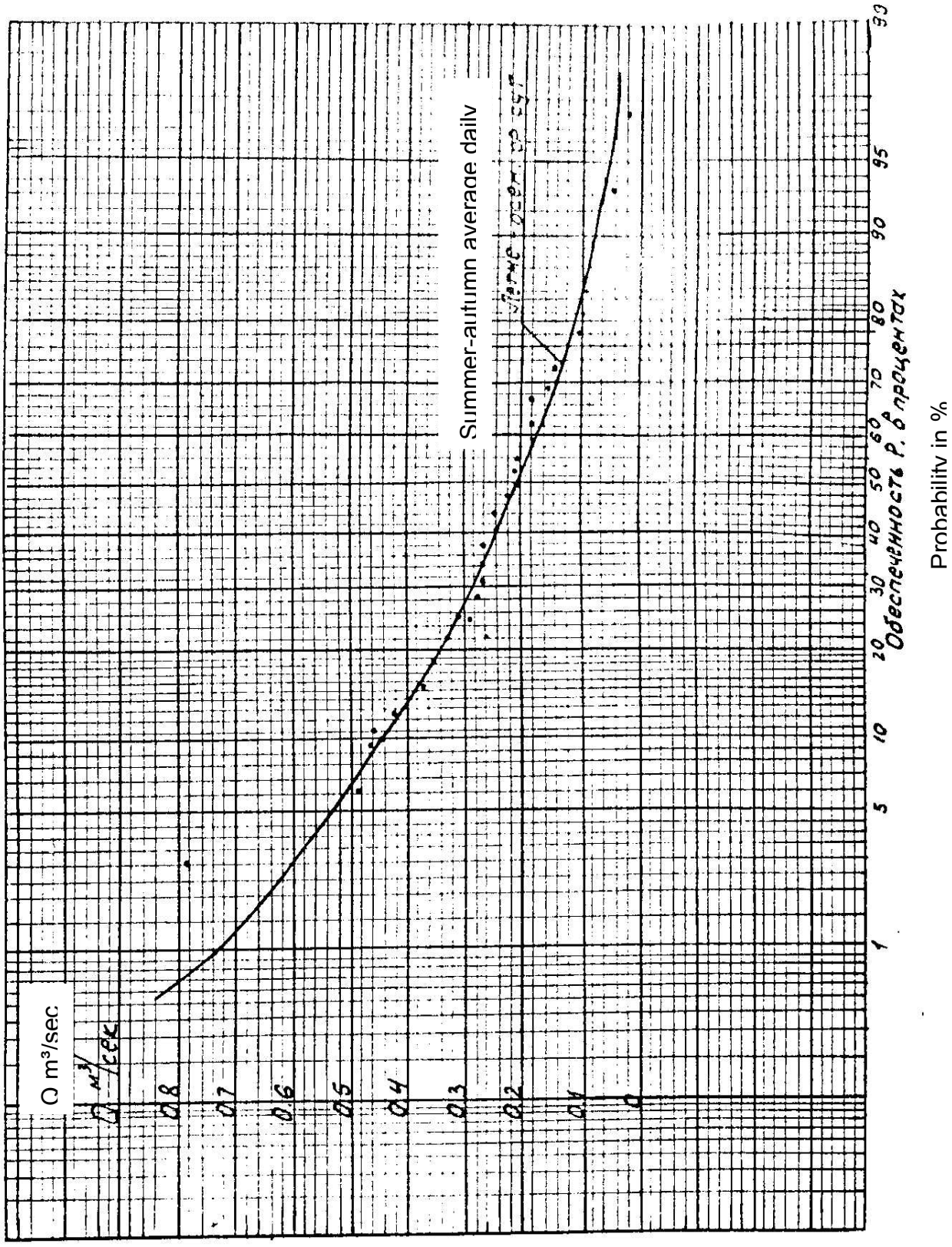


Figure: Probability curves of minimum flow of Gargar River-Kurtan Summer-Autumn Average Daily

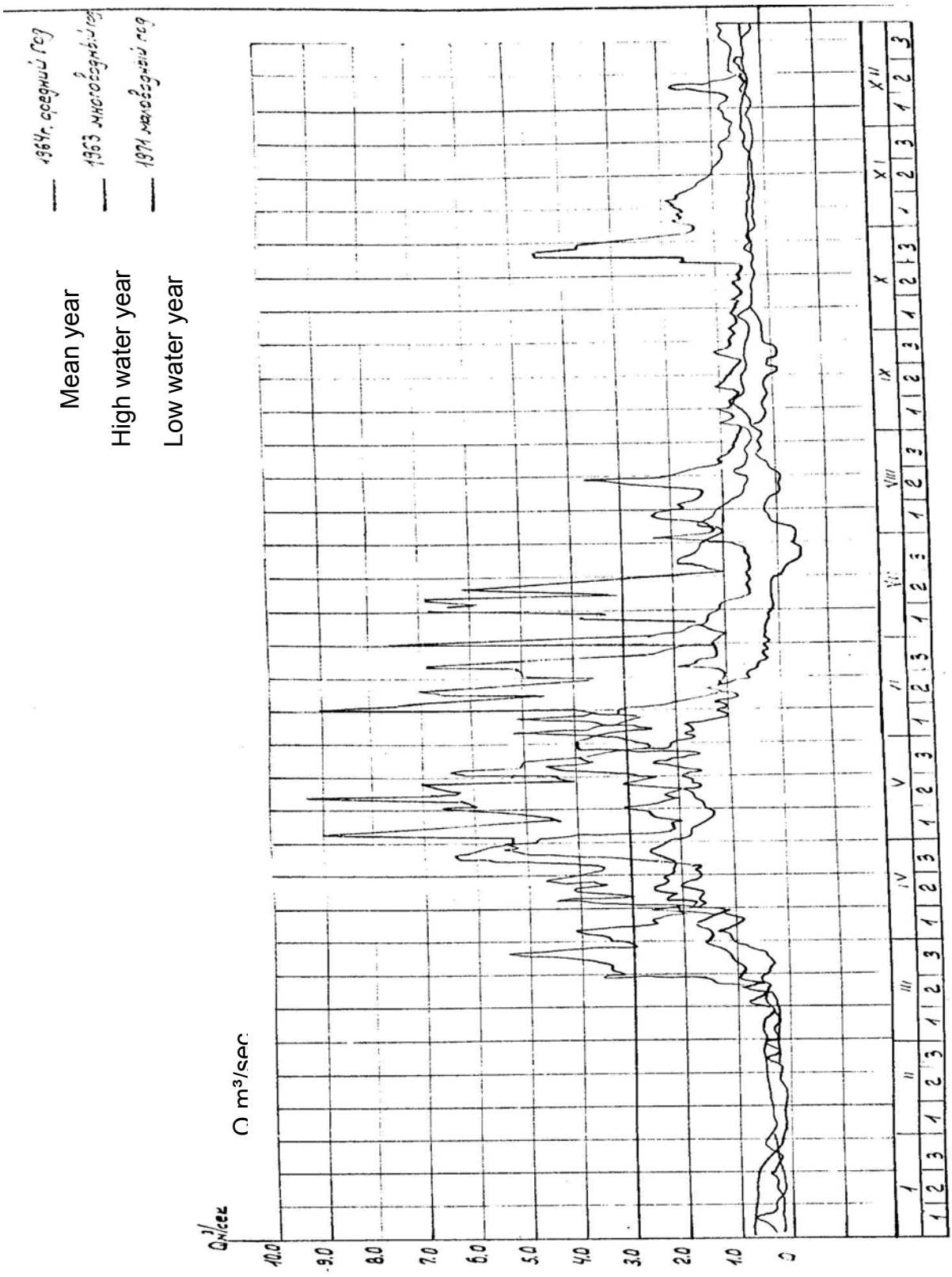


Figure: Discharge record for typical years in Gargar River-Kurtan

Natural Average Monthly and Annual Flows of Gargar River at Village Kurtan

Table: Natural average monthly and annual water discharges of Gargar River-village Kurtan

Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Mean year
1956	0,37	0,42	0,67	3,23	4,49	2,95	1,30	0,54	0,64	0,49	0,37	0,29	**1,31**
1957	0,21	0,45	1,21	2,17	2,60	1,64	1,02	0,33	0,28	0,24	0,25	0,19	**0,88**
1958	0,10	0,13	0,22	1,40	0,96	1,33	0,41	0,55	0,46	0,43	0,25	0,27	**0,54**
1959	0,15	0,15	0,40	3,03	7,58	4,94	3,42	2,83	0,95	1,61	1,17	0,79	**2,25**
1960	0,48	0,80	0,79	4,82	1,28	3,76	1,39	0,54	0,42	0,51	0,32	0,31	**1,29**
1961	0,17	0,21	0,30	0,86	0,67	0,55	1,31	0,32	0,25	0,25	0,24	0,26	**0,45**
1962	0,29	0,28	0,65	1,95	1,77	0,78	0,45	0,29	0,27	0,13	0,24	0,20	**0,61**
1963	0,21	0,21	0,44	3,53	5,34	4,40	3,03	1,60	0,81	1,38	1,17	0,69	**1,90**
1964	0,62	0,45	1,81	2,75	2,85	1,73	1,19	0,95	0,72	0,44	0,29	0,35	**1,18**
1965	0,23	0,36	0,96	2,56	1,48	1,42	1,02	0,48	0,26	1,80	0,66	0,52	**0,98**
1966	0,33	0,35	0,59	1,89	4,68	1,24	1,01	0,31	0,46	0,54	0,29	0,22	**0,99**
1967	0,24	0,21	0,40	3,21	3,09	1,61	3,17	1,18	1,27	0,63	0,83	0,52	**1,37**
1968	0,57	0,83	1,90	6,18	4,38	5,88	2,01	0,89	0,65	0,48	0,47	0,53	**2,07**
1969	0,52	0,39	1,99	6,34	4,34	0,98	0,42	0,37	0,37	0,59	0,37	0,33	**1,42**
1970	0,30	0,34	1,68	2,11	1,03	0,37	0,43	0,73	0,82	0,33	0,23	0,24	**0,72**
1971	0,45	0,28	0,70	1,93	2,07	1,65	0,18	0,21	0,19	0,33	0,21	0,35	**0,71**
1972	0,21	0,32	0,77	3,82	5,55	3,77	1,17	0,76	0,81	0,50	0,38	0,33	**1,53**
1973	0,33	0,49	0,51	3,06	2,31	3,08	1,47	0,59	0,43	0,40	0,61	0,33	**1,13**
1974	0,21	0,29	1,43	4,70	3,53	1,45	0,69	1,10	2,47	0,58	0,38	0,40	**1,43**
1975	0,38	0,33	0,97	2,62	4,66	1,51	0,68	0,45	0,35	1,07	0,46	0,33	**1,15**
1976	0,48	0,41	0,92	4,78	4,39	2,88	2,09	0,65	0,57	0,47	0,35	0,34	**1,53**
1977	0,32	0,40	0,57	2,07	2,57	1,17	0,85	0,31	0,75	0,70	0,45	0,31	**0,87**
1978	0,30	0,81	1,57	5,46	5,68	3,70	0,93	0,87	0,57	0,46	0,38	0,31	**1,75**
1979	0,27	0,29	0,65	2,42	1,79	4,11	2,00	0,50	0,34	0,51	0,79	0,39	**1,17**
1980	0,32	0,31	1,09	3,36	2,85	0,47	0,37	0,46	0,28	0,29	0,24	0,24	**0,86**
1981	0,32	0,36	0,41	1,48	2,98	2,19	1,28	1,14	0,53	0,48	0,46	0,30	**1,00**
1982	0,27	0,30	0,48	3,67	2,64	2,16	1,18	1,05	0,45	0,49	0,44	0,41	**1,13**
1983	0,32	0,27	0,72	1,93	3,18	1,97	1,25	0,65	0,67	0,55	2,77	0,75	**1,25**
1984	0,26	0,31	1,69	4,29	3,57	1,68	0,80	0,53	0,44	0,33	0,63	0,35	**1,24**
1985	0,24	0,34	0,79	2,55	2,42	1,63	0,79	0,47	0,30	0,34	0,33	0,29	**0,88**
1986	0,44	0,24	0,55	2,49	3,92	5,10	0,99	0,53	0,32	0,40	0,61	0,33	**1,33**
1987	0,50	0,68	0,79	3,43	2,52	1,83	0,42	0,63	0,47	0,58	1,20	0,77	**1,15**
1988	0,53	0,46	1,51	4,43	5,14	5,06	3,19	3,32	1,21	1,45	1,12	0,84	**2,36**
1989	0,66	0,65	1,00	1,53	0,70	0,68	0,81	0,41	0,39	0,84	1,41	1,38	**0,87**
1990	0,48	0,68	2,13	3,96	3,59	0,98	0,47	0,73	0,78	0,70	1,53	0,69	**1,40**
1991	0,74	0,75	3,00	4,36	2,47	1,41	0,60	0,54	0,44	0,42	0,52	0,47	**1,31**
1993	0,68	0,69	1,33	2,50	4,32	2,09	0,79	0,79	0,63	0,56	0,66	0,77	**1,32**
1994	0,59	0,85	1,02	2,92	2,35	1,21	0,87	1,26	0,61	0,57	0,74	0,98	**1,17**
1995	0,68	0,62	1,51	3,53	2,37	2,17	1,47	0,46	0,59	0,98	0,63	0,56	**1,30**
1996	0,51	0,62	0,81	5,80	3,94	2,11	0,82	0,73	0,67	0,72	0,69	0,64	**1,51**
1997	0,60	0,69	0,73	4,13	2,90	2,28	1,33	1,10	1,75	1,54	0,76	0,92	**1,56**
1998	0,55	0,56	0,85	3,41	4,07	3,39	1,21	1,48	1,37	0,54	0,64	0,84	**1,58**
1999	0,57	0,75	0,92	3,05	3,45	3,14	1,15	0,69	0,95	0,70	0,75	0,68	**1,40**
2000	0,64	0,67	0,92	4,84	3,44	1,94	0,47	0,37	0,29	0,72	0,56	0,73	**1,30**
2001	0,63	0,54	2,04	3,74	3,19	1,08	0,47	0,26	0,26	0,34	0,34	0,37	**1,11**
Average	**0,41**	**0,46**	**1,03**	**3,30**	**3,22**	**2,26**	**1,16**	**0,78**	**0,63**	**0,63**	**0,63**	**0,49**	**1,25**

River X- Sections and corresp. Discharge-Rating Curves

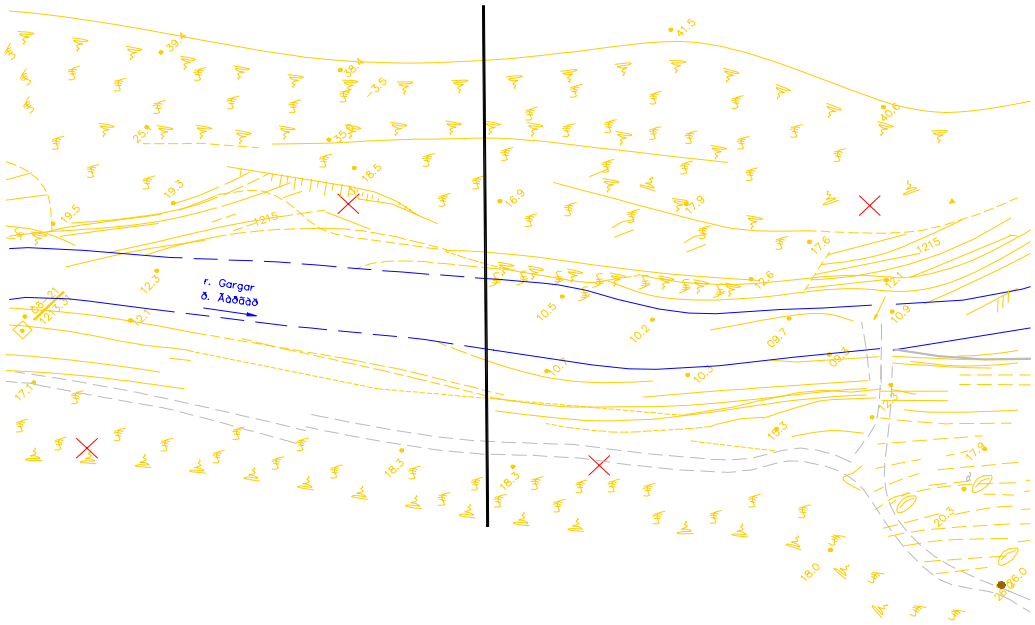


Figure: Plan view of x-section at weir site

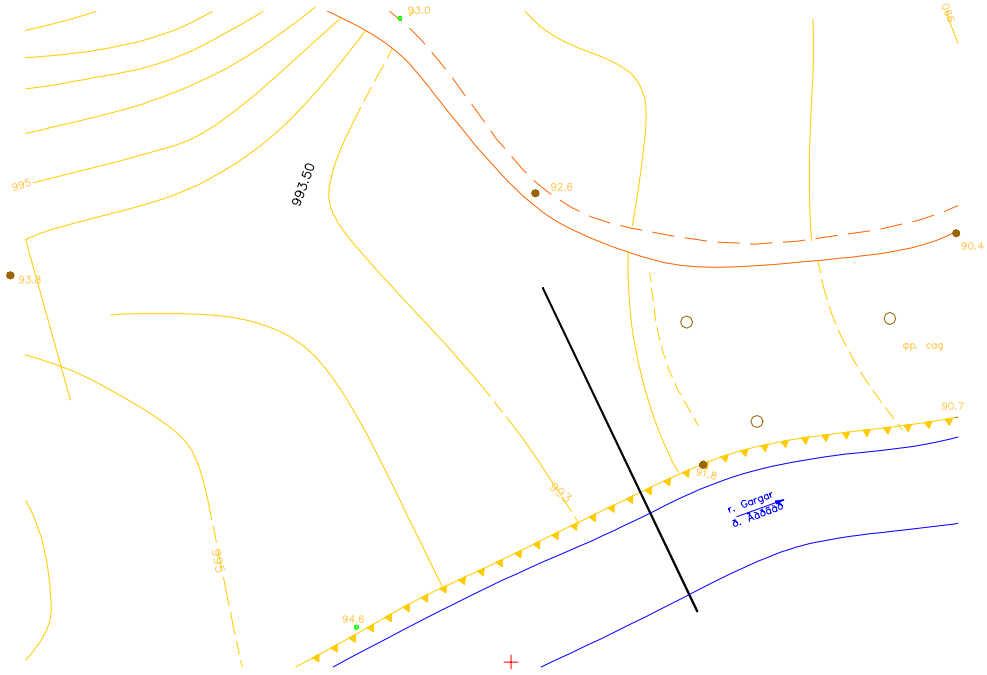


Figure: Plan view of x-section at powerhouse site

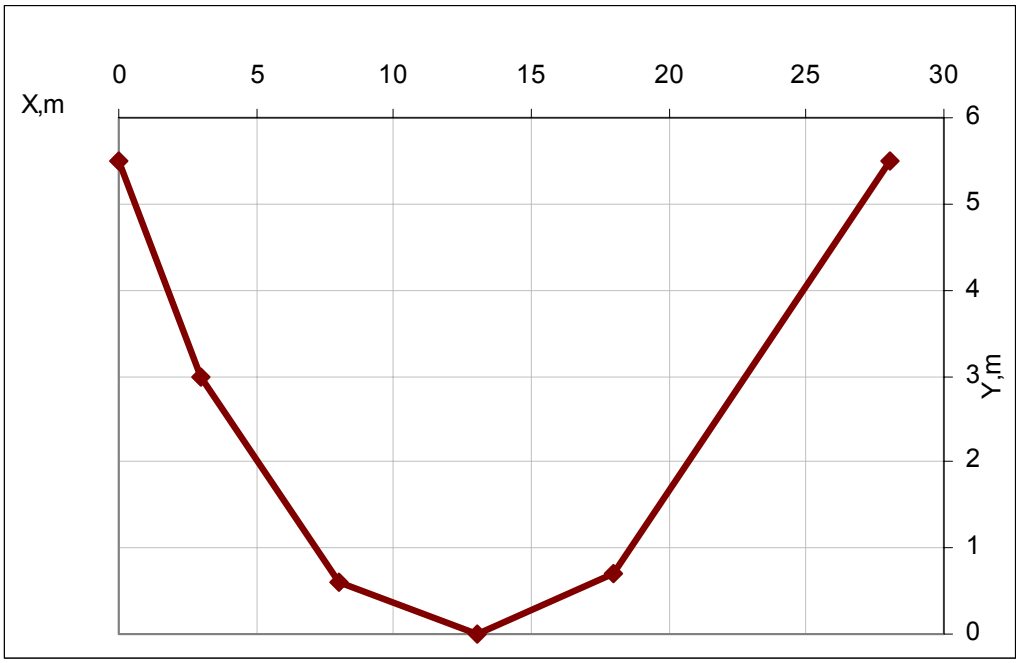


Figure: X-section at weir site

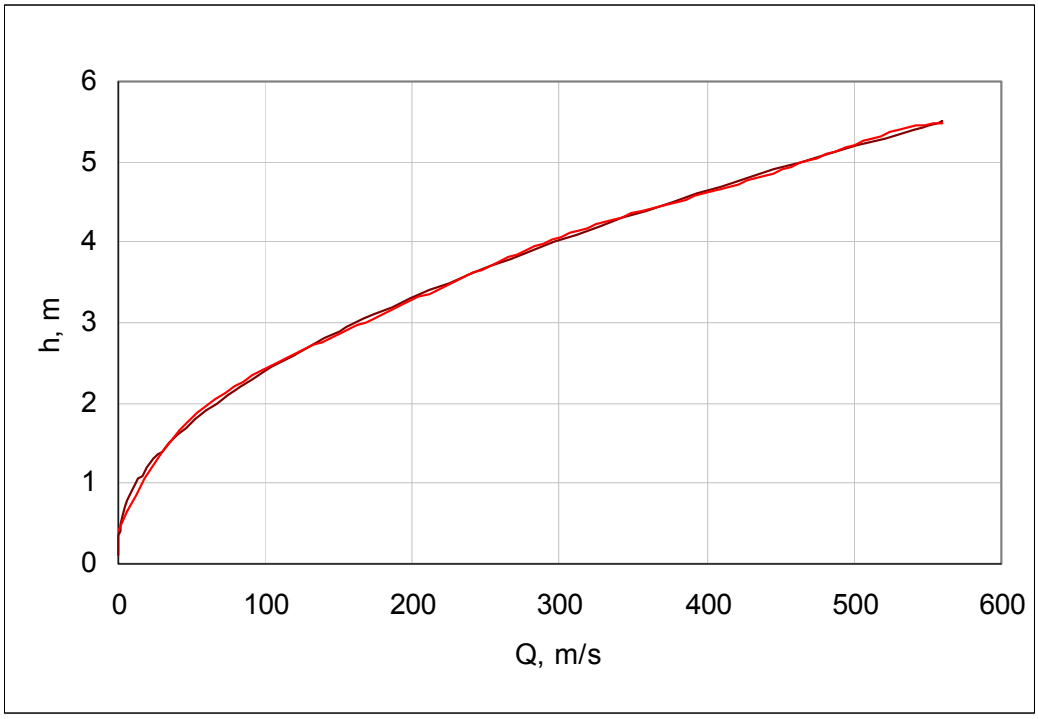


Figure: Discharge Rating Curve at weir site

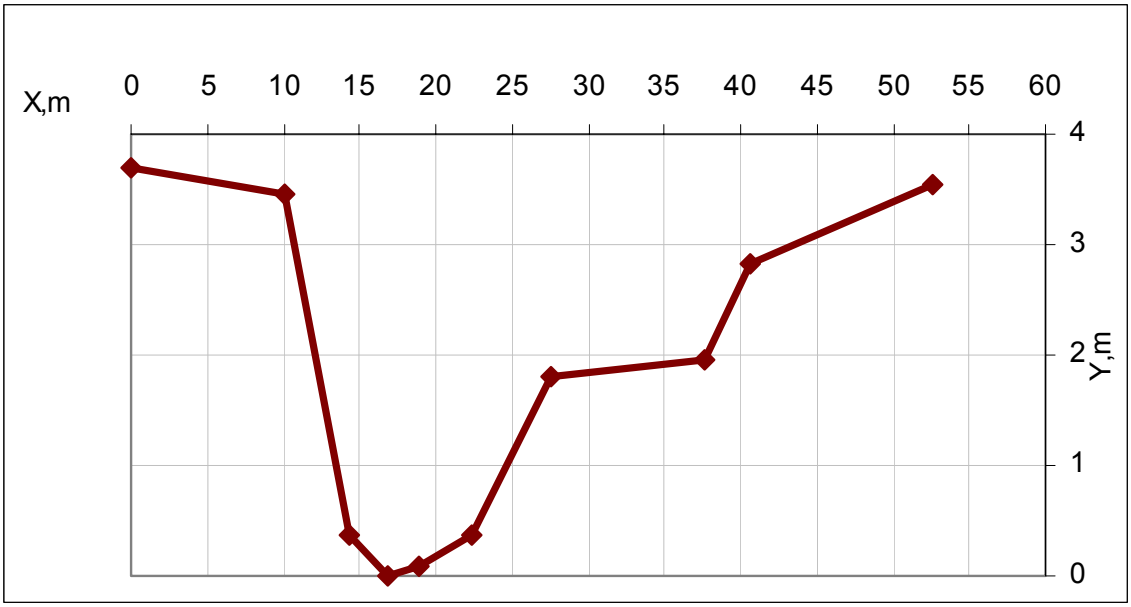


Figure: X-section at powerhouse site

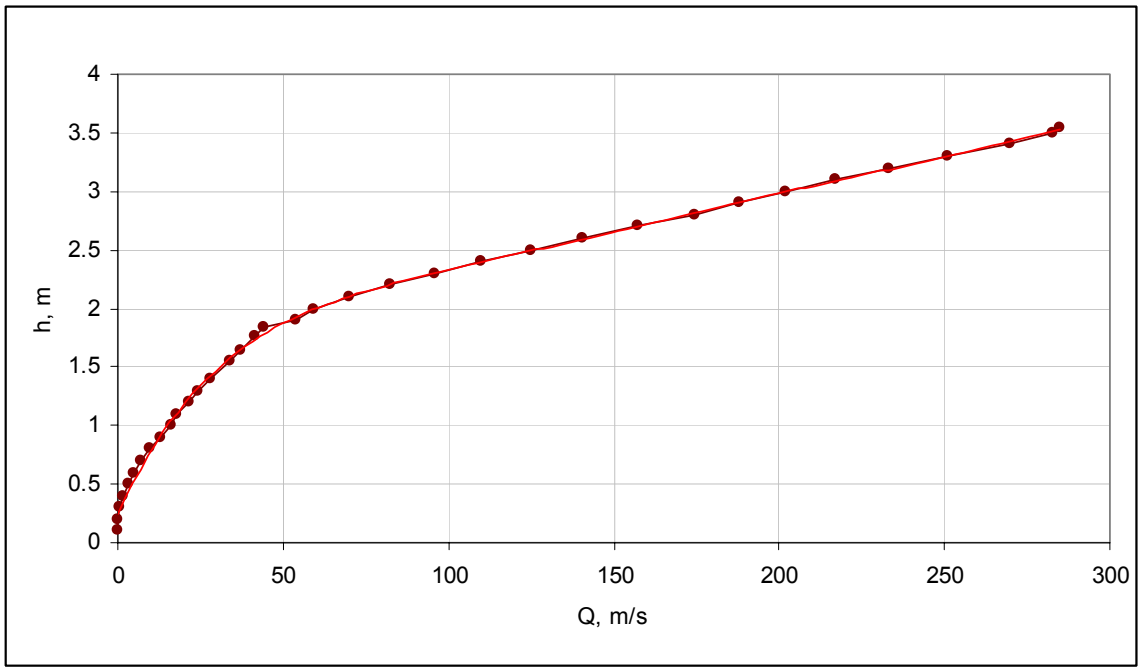


Figure: Discharge Rating Curve at powerhouse site

4.4

Sediment Transport

Table of Content

Bed Material

Table: Bed Material
Grain Size Distribution

	Gargar I	Gargar II	Gargar III	All
Sieve [mm]	Percentage of Weight [%]	Percentage of Weight [%]	Percentage of Weight [%]	Percentage of Weight [%]
0	0.81	0.56	0.56	0.56
0.1	3.02	2.09	2.09	2.1
1	8.08	5.59	5.59	5.61
4	16.15	11.18	11.18	11.23
10	25.54	17.68	17.68	17.75
20	36.11	25	25	25.11
30	44.23	27.17	27.9	28.82
40	51.07	39.61	34.54	38.63
60	62.55	57.1	52.82	56.6
80	71.82	75.05	70.57	72.22
100	86.63	87.91	82.68	85.25
120	90.73	93.24	90.98	91.59
150	95.55	97.42	96.56	96.56
200	100	100	100	100

Bed Load

Table: Bed Load
Mean Monthly Transport
of Fine Material (<8-16mm) in [t/m]

Year	January	February	March	April	May	June	July	August	September	October	November	December	Volume
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	13	1	9	0	3	0	0	0	0	26
1959	0	0	0	47	77	55	34	18	0	4	1	0	236
1960	0	0	7	25	5	23	9	0	0	0	0	0	69
1961	0	0	0	0	0	0	7	0	0	0	0	0	7
1962	0	0	0	11	20	0	0	0	0	0	0	0	31
1963	0	0	0	53	68	71	29	10	0	23	3	1	258
1964	0	0	34	41	58	8	3	0	0	0	0	0	145
1965	0	0	3	34	7	12	0	0	0	16	0	0	73
1966	0	0	0	19	59	6	5	0	0	0	0	0	89
1967	0	0	0	22	60	12	53	1	4	0	0	0	152
1968	0	4	21	31	64	55	30	0	0	0	0	0	205
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	19	24	6	0	0	1	4	0	0	0	53
1971	0	0	0	16	26	20	0	0	0	0	0	0	62
1972	0	0	2	69	41	60	2	1	0	0	0	0	175
1973	0	0	0	57	22	82	3	0	0	0	0	0	163
1974	0	0	17	30	38	4	0	8	20	0	0	0	117
1975	0	0	3	40	80	2	0	0	0	0	0	0	126
1976	0	0	8	89	72	62	29	0	0	0	0	0	260
1977	0	0	0	31	40	2	0	0	0	1	0	0	74
1978	0	3	15	48	55	66	1	0	0	0	0	0	188
1979	0	0	0	28	11	61	25	0	0	0	0	0	127
1980	0	0	13	77	43	0	0	0	0	0	0	0	134
1981	0	0	0	17	53	16	7	2	0	0	0	0	95
1982	0	0	0	57	42	21	5	7	0	0	0	0	131
1983	0	0	3	16	41	20	8	0	0	0	40	0	127
1984	0	0	26	66	69	11	0	0	0	0	0	0	173
1985	0	0	1	40	32	9	0	0	0	0	0	0	82
1986	0	0	0	34	53	61	13	0	0	0	0	0	161
1987	0	0	0	53	48	7	0	0	0	0	1	0	109
1988	0	0	12	61	90	67	38	27	2	7	0	0	305
1989	0	0	0	10	0	0	1	0	0	0	8	5	24
1990	0	0	35	67	100	2	0	0	0	0	17	0	220
1991	0	0	22	71	20	12	0	0	0	0	0	0	124
1992	11	11	31	52	51	0	47	23	19	18	18	19	300
1993	0	0	9	71	63	27	0	0	0	0	0	0	170
1994	0	0	1	44	39	5	0	1	0	0	0	0	91
1995	0	0	12	58	31	29	8	0	0	5	0	0	144
1996	0	0	8	48	92	21	0	0	0	0	0	0	169
1997	0	0	0	64	65	31	9	10	23	8	0	0	210
1998	0	0	0	43	68	8	3	7	16	0	1	1	147
1999	0	0	0	59	56	35	3	0	1	0	0	0	152
2000	0	0	5	64	96	27	0	0	0	0	0	0	192
2001	0	0	18	26	44	0	0	0	0	0	0	0	89
Mean	0	0	7	42	46	23	8	3	2	2	2	1	136
Min	0	0	0	0	0	0	0	0	0	0	0	0	0
Max	11	11	35	89	100	82	53	27	23	23	40	19	305

Table: Bed Load
Mean Monthly Transport
of Coarse Material (>8-16mm) in [t/m]

Year	January	February	March	April	May	June	July	August	September	October	November	December	Volume
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	0	0	0	0	0	0	0	0	0	0
1959	0	0	0	65	467	2942	111	195	0	63	0	0	3844
1960	0	0	0	931	0	2382	9	0	0	0	0	0	3323
1961	0	0	0	0	0	0	11	0	0	0	0	0	11
1962	0	0	0	19	0	0	0	0	0	0	0	0	19
1963	0	0	0	104	367	216	108	0	0	0	0	0	795
1964	0	0	12	33	0	31	0	0	0	0	0	0	75
1965	0	0	0	115	0	0	0	0	0	22	0	0	137
1966	0	0	0	0	664	0	0	0	0	0	0	0	664
1967	0	0	0	140	31	15	117	0	0	0	0	0	303
1968	0	0	0	584	183	510	0	0	0	0	0	0	1277
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	64	20	0	0	0	0	0	0	0	0	84
1971	0	0	0	0	0	9	0	0	0	0	0	0	9
1972	0	0	0	77	711	108	0	0	0	0	0	0	897
1973	0	0	0	34	52	10	0	0	0	0	0	0	96
1974	0	0	0	2216	137	0	0	0	61	0	0	0	2414
1975	0	0	0	0	274	0	0	0	0	0	0	0	274
1976	0	0	0	193	244	0	0	0	0	0	0	0	437
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	531	787	95	0	0	0	0	0	0	1413
1979	0	0	0	28	0	152	0	0	0	0	0	0	179
1980	0	0	0	27	72	0	0	0	0	0	0	0	99
1981	0	0	0	0	22	63	0	0	0	0	0	0	85
1982	0	0	0	93	0	66	0	0	0	0	0	0	158
1983	0	0	0	0	149	0	0	0	0	0	424	0	573
1984	0	0	40	182	144	0	0	0	0	0	0	0	366
1985	0	0	0	0	17	0	0	0	0	0	0	0	17
1986	0	0	0	0	162	474	0	0	0	0	0	0	636
1987	0	0	0	121	0	57	0	0	0	0	0	0	177
1988	0	0	0	259	570	1586	148	836	0	0	0	0	3399
1989	0	0	0	0	0	0	0	0	0	0	19	12	30
1990	0	0	0	102	10	0	0	0	0	0	9	0	121
1991	0	0	261	190	108	0	0	0	0	0	0	0	559
1992	0	0	227	431	770	2155	0	0	0	0	0	0	3582
1993	0	0	0	44	238	0	0	0	0	0	0	0	282
1994	0	0	0	54	24	0	0	0	0	0	0	0	78
1995	0	0	0	100	10	0	0	0	0	0	0	0	111
1996	0	0	0	446	67	10	0	0	0	0	0	0	524
1997	0	0	0	173	0	0	11	0	0	0	0	0	185
1998	0	0	0	114	237	235	0	41	0	0	0	0	627
1999	0	0	0	12	149	61	0	0	0	0	0	0	222
2000	0	0	0	262	0	0	0	0	0	0	0	0	262
2001	0	0	0	329	169	0	0	0	0	0	0	0	499
Mean	0	0	14	182	155	254	12	24	1	2	10	0	655
Min	0	0	0	0	0	0	0	0	0	0	0	0	0
Max	0	0	261	2216	787	2942	148	836	61	63	424	12	3844

Table: Bed Load
Mean Monthly Transport
Total Material in [t/m]

Year	January	February	March	April	May	June	July	August	September	October	November	December	Volume
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	0	0	0	13	1	9	0	3	0	0	0	0	26
1959	0	0	0	113	544	2997	145	213	0	67	1	0	4080
1960	0	0	7	956	5	2405	18	0	0	0	0	0	3392
1961	0	0	0	0	0	0	18	0	0	0	0	0	18
1962	0	0	0	29	20	0	0	0	0	0	0	0	50
1963	0	0	0	158	435	287	136	10	0	23	3	1	1053
1964	0	0	45	74	58	39	3	0	0	0	0	0	220
1965	0	0	3	149	7	12	0	0	0	38	0	0	209
1966	0	0	0	19	723	6	5	0	0	0	0	0	753
1967	0	0	0	162	91	27	170	1	4	0	0	0	455
1968	0	4	21	614	246	565	30	0	0	0	0	0	1481
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	0	82	43	6	0	0	1	4	0	0	0	137
1971	0	0	0	16	26	29	0	0	0	0	0	0	72
1972	0	0	2	146	753	167	2	1	0	0	0	0	1071
1973	0	0	0	91	74	92	3	0	0	0	0	0	259
1974	0	0	17	2246	175	4	0	8	81	0	0	0	2531
1975	0	0	3	40	354	2	0	0	0	0	0	0	399
1976	0	0	8	282	316	62	29	0	0	0	0	0	697
1977	0	0	0	31	40	2	0	0	0	1	0	0	74
1978	0	3	15	579	842	161	1	0	0	0	0	0	1601
1979	0	0	0	56	11	213	25	0	0	0	0	0	306
1980	0	0	13	104	116	0	0	0	0	0	0	0	233
1981	0	0	0	17	75	79	7	2	0	0	0	0	180
1982	0	0	0	150	42	87	5	7	0	0	0	0	290
1983	0	0	3	16	190	20	8	0	0	0	464	0	700
1984	0	0	67	248	213	11	0	0	0	0	0	0	539
1985	0	0	1	40	49	9	0	0	0	0	0	0	99
1986	0	0	0	34	215	534	13	0	0	0	0	0	797
1987	0	0	0	173	48	63	0	0	0	0	1	0	286
1988	0	0	12	320	660	1654	186	863	2	7	0	0	3704
1989	0	0	0	10	0	0	1	0	0	0	26	17	55
1990	0	0	35	168	110	2	0	0	0	0	26	0	342
1991	0	0	283	261	127	12	0	0	0	0	0	0	683
1992	11	11	257	483	820	2155	47	23	19	18	18	19	3882
1993	0	0	9	115	301	27	0	0	0	0	0	0	452
1994	0	0	1	99	62	5	0	1	0	0	0	0	169
1995	0	0	12	158	41	29	8	0	0	5	0	0	255
1996	0	0	8	495	160	32	0	0	0	0	0	0	694
1997	0	0	0	238	65	31	21	10	23	8	0	0	395
1998	0	0	0	157	305	243	3	48	16	0	1	1	774
1999	0	0	0	71	204	96	3	0	1	0	0	0	374
2000	0	0	5	326	96	27	0	0	0	0	0	0	454
2001	0	0	18	355	213	0	0	0	0	0	0	0	587
Mean	0	0	21	224	201	277	20	27	3	4	12	1	791
Min	0	0	0	0	0	0	0	0	0	0	0	0	0
Max	11	11	283	2246	842	2997	186	863	81	67	464	19	4080

Suspended Load

Table: Suspended Load
Measured Mean Concentration [g/m^3]

Decade	January	February	March	April	May	June	July	August	September	October	November	December
1	0.00	0.00	0.00	76.00	50.00	130.00	120.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	230.00	26.00	500.00	31.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	76.00	330.00	280.00	73.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	127.33	135.33	303.33	74.67	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	60.00	37.00	32.00	43.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	16.00	34.00	44.00	4.20	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	69.00	37.00	56.00	16.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	0.00	0.00	48.33	36.00	44.00	21.07	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	520.00	420.00	200.00	11.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	400.00	270.00	28.00	9.40	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	580.00	64.00	120.00	13.00	0.00	0.00	0.00	0.00	0.00
1978	0.00	0.00	0.00	500.00	251.33	116.00	11.13	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	92.00	33.00	71.00	130.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	64.00	46.00	81.00	44.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	59.00	29.00	220.00	15.00	0.00	0.00	0.00	0.00	0.00
1979	0.00	0.00	0.00	71.67	36.00	124.00	63.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	13.00	82.00	10.00	11.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	58.00	34.00	66.00	6.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	59.00	34.00	26.00	26.00	0.00	0.00	0.00	0.00	0.00
1980	0.00	0.00	0.00	43.33	50.00	34.00	14.33	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
1981	0.00	0.00	0.00	64.00	53.00	33.00	85.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
1982	0.00	0.00	0.00	98.00	22.00	19.00	23.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
1983	0.00	0.00	0.00	10.00	30.00	40.00	13.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
1984	0.00	0.00	0.00	180.00	120.00	22.00	20.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
1985	0.00	0.00	0.00	120.00	83.00	530.00	74.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
1986	0.00	0.00	0.00	44.00	220.00	410.00	49.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
1987	0.00	0.00	0.00	90.00	51.00	86.00	28.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00					0.00	0.00	0.00	0.00	0.00
1988	0.00	0.00	0.00	190.00	590.00	420.00	280.00	0.00	0.00	0.00	0.00	0.00

Table: Suspended Load
Mean Monthly Transport [t/m]

Year	January	February	March	April	May	June	July	August	September	October	November	December	Sum
1958													
1959													
1960													
1961													
1962													
1963													
1964													
1965													
1966													
1967													
1968													
1969													
1970													
1971													
1972													
1973													
1974													
1975													
1976	0	0	0	1571	1583	2194	401	0	0	0	0	0	5748
1977	0	0	0	257	238	123	41	0	0	0	0	0	659
1978	0	0	0	7053	3811	1084	25	0	0	0	0	0	11973
1979	0	0	0	446	167	1295	323	0	0	0	0	0	2231
1980	0	0	0	377	379	39	12	0	0	0	0	0	807
1981	0	0	0	246	422	183	264	0	0	0	0	0	1115
1982	0	0	0	908	155	105	70	0	0	0	0	0	1237
1983	0	0	0	50	254	200	42	0	0	0	0	0	546
1984	0	0	0	1997	1136	93	39	0	0	0	0	0	3266
1985	0	0	0	792	522	2118	128	0	0	0	0	0	3560
1986	0	3	0	283	2271	5347	143	0	0	0	0	0	8046
1987	0	0	0	800	330	397	28	0	0	0	0	0	1555
1988	0	0	0	2182	8103	5456	2350	0	0	0	0	0	18090
1989													
1990													
1991													
1992													
1993													
1994													
1995													
1996													
1997													
1998													
1999													
2000													
2001													
mean	0	0	0	1305	1490	1433	297	0	0	0	0	0	4526
min	0	0	0	50	155	39	12	0	0	0	0	0	546
max	0	3	0	7053	8103	5456	2350	0	0	0	0	0	18090

4.5

Geology

Table of Content

Photos

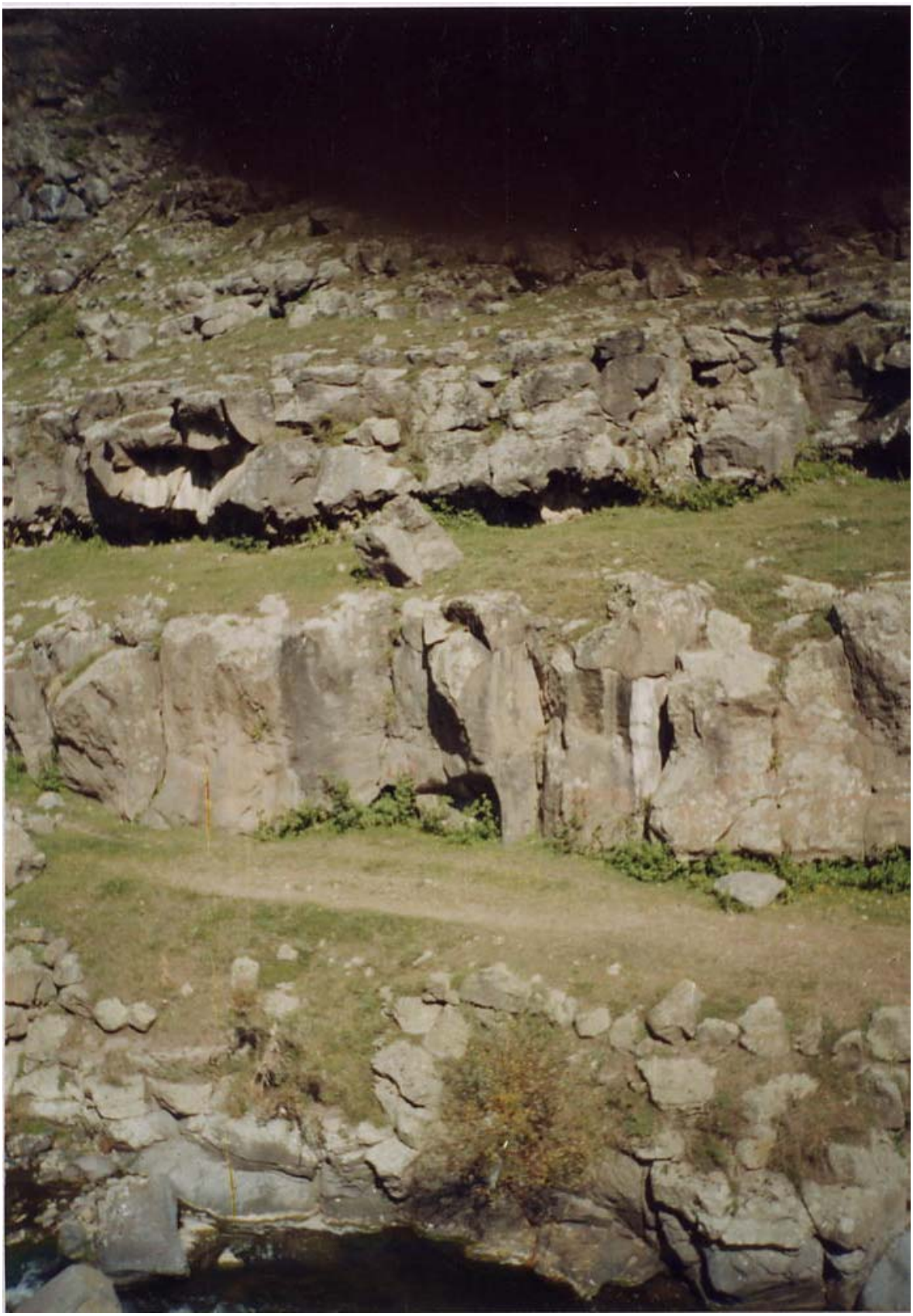


Photo 1: Basalt Streams on the left bank of Gargar River near weirsite

Photo 2: Tectonic split –sliding on the right bank of Gargar River along the penstock alignment

Photo 3: Volcanic-loose sands on the left bank of Gargar River along the penstock alignment

Photo 4: Accumulation of big boulders of basalts on the right bank of Gargar River along the penstock alignment

Photo 5: SHPP powerhouse area

Table: Engineering-Geological Characteristics of Rocks

Geological index	Layer number	Legend	The description of the rocks	Ground density kg/m^3	Ground particle density kg/m^3	The resistance indexes of rocks shifting		The deformation modulus Mpa		Admissible foundation pressure R_0 Mpa	Firmness limits as per compression E, MPa		Rocks category according to SNiP	Filtration coefficient m/daily	Water content	Corrosiveness of the water (medium)	The rocks category according to the seismic qualities	Notes
						tg f	C, Mpa	E-static	E-dynamic		dry sample	water-saturated sample						
dcQ_4	1		Big boulders, detritus and gravels mainly of basalts with silty-clay, silty-sand filling up to 30 %, in some places there is no filling	1900-2100	2800	0,700	0,001	80	90	0,5			VII,10$^{e*)}$	>10,0	High	Non-corrosive	II	The category is given according to SNiP
cQ_4	1^a		Big boulders (the size is up to 4m), detritus and gruss of basalts, porphyries, tuffs, metasandstones and other rocks with silty-sand filling 20-30 %, in some places there is no filling. Sliding rocks are present as well.	1900-2100	2800	0,700	0,001	100	120	0,5			VII,10$^{e*)}$	>10,0	High	Non-corrosive	II	The category is given according to SNiP
acQ_4	2		Pebble, gravel as well as big boulders (2-3m) and detritus from different bedrocks with sand and silty-sand filling to 25%.	1800-2000	2700	0,700	0,001	80	90	0,5			VII,10$^{e*)}$	5,0	High	Non-corrosive	II	The category is given according to SNiP
dpQ_4	3		Silty-clays and silty-sands with boulders of detritus and gruss of different bedrocks up to 40-45%.	1700	2700	0,466	0,02	15	18	0,25			IV,10^e	0,05	Dry		III	
βQ_4	5		Gray, compact, porous and fractured doleritic basalts with thin layers of volcanic ashes.	2600	2930	0,839	0,3	30000	35000	>0,6	92,5	61,0	10% -VII, 20$^{a*)}$ 50% VIII,20$^{б*)}$ 40%-IX,20$^{в*)}$	~20,0	High	Non-corrosive	I	The category is given according to SNiP
	5^a		Brown , fine-grained, weathered and loose volcanic sands	1800	2800	0,532	0,002	18	20	0,2			I, 27^a	~5,0	Dry		II	
β_{1-2}	9^a		Thick, highly fractured and hydrothermally altered porphyries (plagioclase), tuffs, metasandstones and marls	2400-2500	2700	0,781	0,05	25000	30000	>0,6			VII, 20$^{a*)}$	~0,1	Slight	Non-corrosive	I	The category is given according to SNiP
	11		Volcanic-sedimentary rocks as a result of mylonitization transformed into white flour-like substance. Zone of tectonic stresses	1400	2600	0,577	0,01	50	60	0,10			I, 27^a	0,05	Dry		III	

Borehole Samples

Figure: Weirsite of Gargar SHPP. BH 20, Depth: 0-9

Figure: Weirsite of Gargar SHPP. BH 20, Depth: 9-15

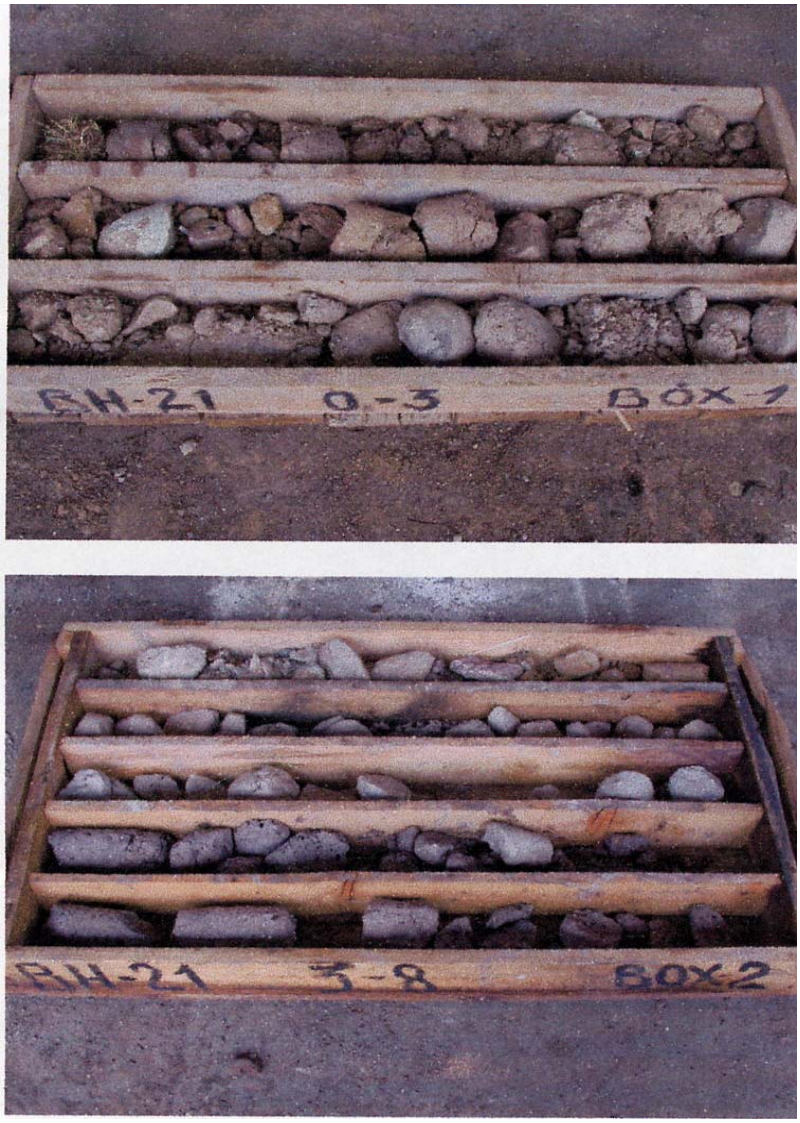


Figure: Weirsite of Gargar SHPP. BH 21, Depth: 0-8

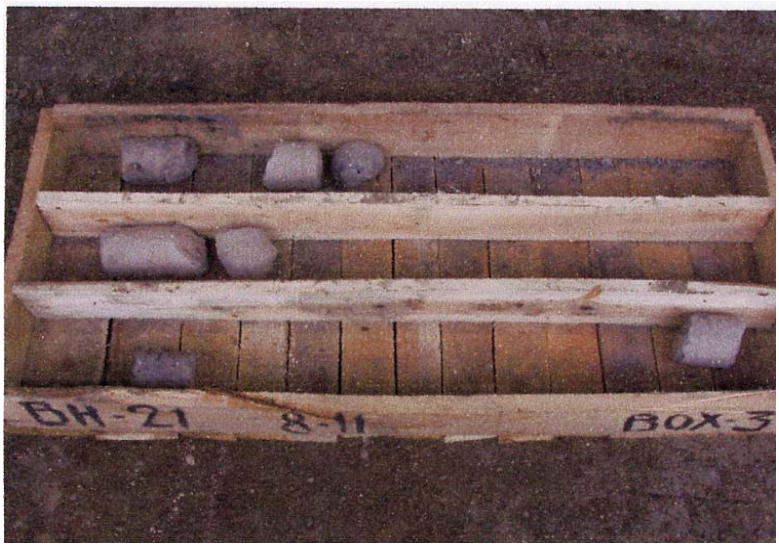


Figure: Weirsite of Gargar SHPP. BH 21, Depth: 8-14

Figure: Powerhouse area of Gargar SHPP. BH 15, Depth: 0-15

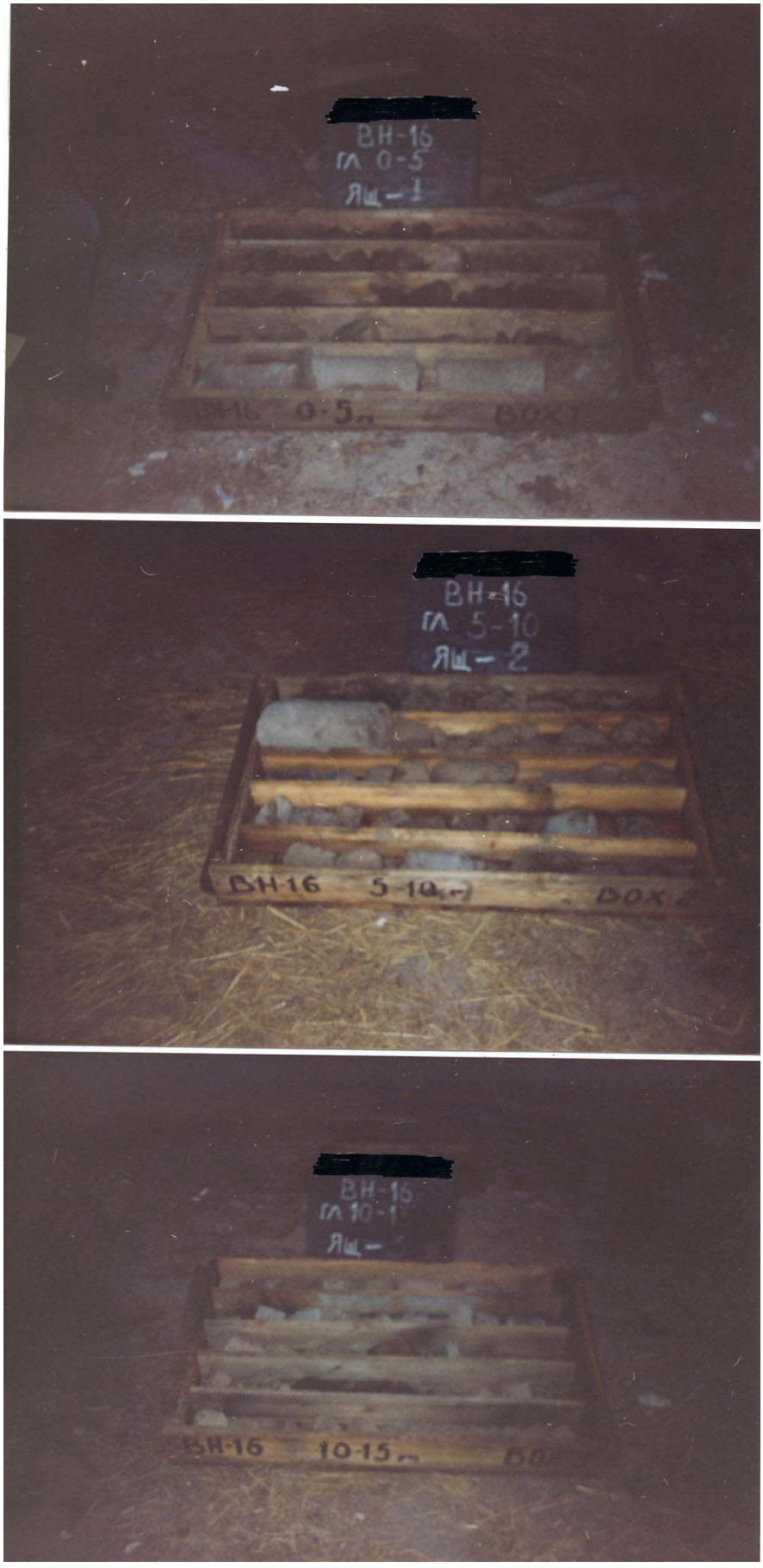


Figure: Powerhouse area of Gargar SHPP. BH 16, Depth: 0-15

Figure: Powerhouse area of Gargar SHPP. BH 17, Depth: 0-15

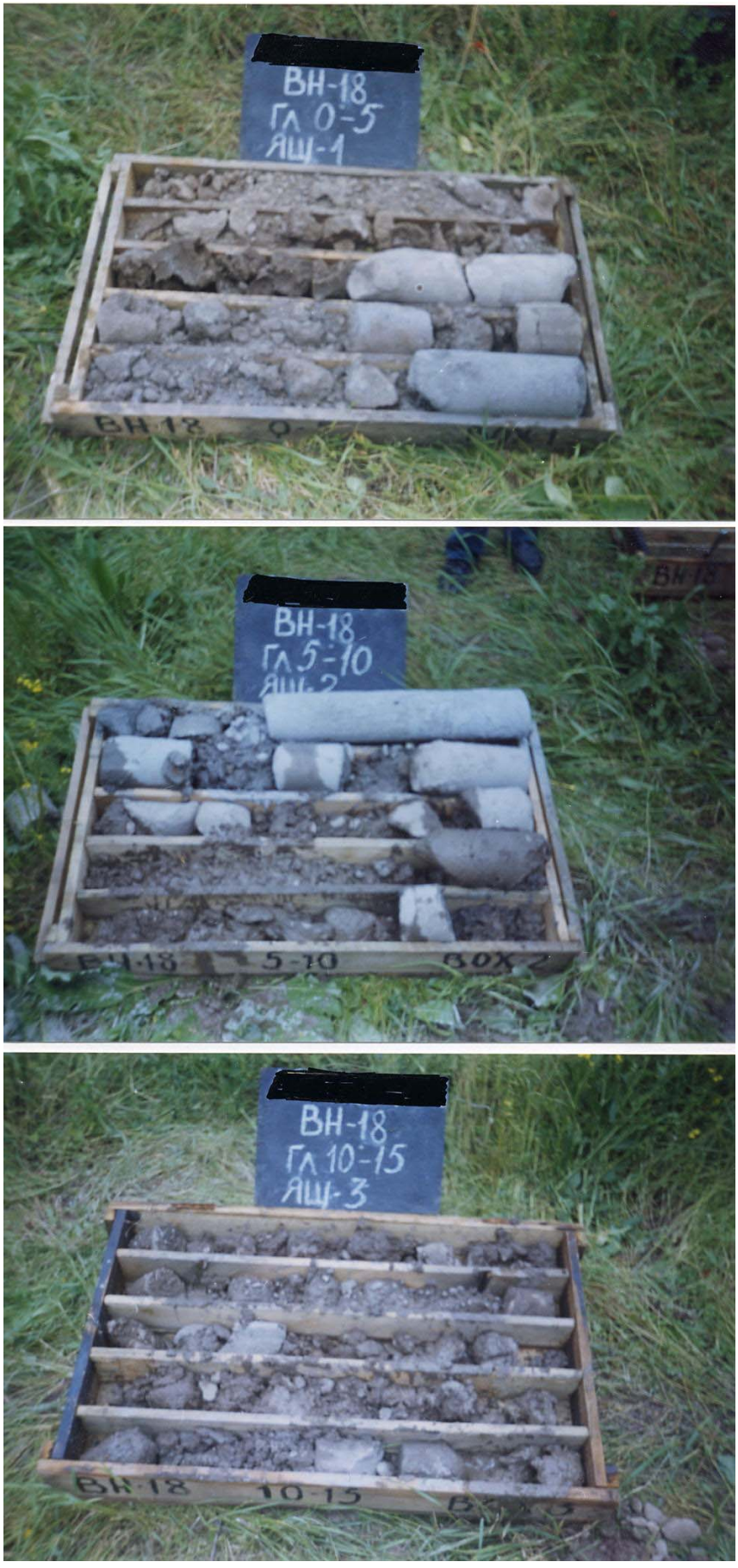


Figure: Powerhouse area of Gargar SHPP. BH 18, Depth: 0-15

Borehole Logs

Table: Borehole 15

BOREHOLE 15 Absolute Elevation 996.8 masl										
Depth m	Layer bottom depth m	Absolute elevation of layer bottom in m	Description of Rock/Soil	Degree of Weatheredness	Orientation	Roughness	Filling material	Joints/m	Core REC%	RQD%
1	0,5	996.3	Topsoil with silty sands and detritus						60	
			Pebble and gravel				sylty -sand and sand (5%)			
2			Pebble and gravel				sylty -sand and sand (5%)			
3			Pebble and gravel				sylty -sand and sand (5%)			
4			Pebble and gravel				sylty -sand and sand (5%)			
	4.0	992.8	Pebble and gravel						95	
5			Pebble and gravel				sand and silty clay (20%)			
6			Pebble and gravel				sand and silty clay (20%)			
7			Pebble and gravel				sand and silty clay (20%)			
8			Pebble and gravel				sand and silty clay (20%)			
9			Pebble and gravel				sand and silty clay (20%)			
10			Pebble and gravel				sand and silty clay (20%)			
11			Pebble and gravel				sand and silty clay (20%)			
12			Pebble and gravel				sand and silty clay (20%)			
13			Pebble and gravel				sand and silty clay (20%)			
14			Pebble and gravel				sand and silty clay (20%)			
15			Pebble and gravel				sand and silty clay (20%)			
	15.0	981.8							80	
			End of borehole							

Table: Borehole 16

BOREHOLE 16 Absolute Elevation 995.7 masl										
Depth, m	Layer bottom depth m	Absolute elevation of layer bottom in m	Description of Rock/Soil	Degree of Weatheredness	Orientation	Roughness	Filling material	Joints/m	Core REC%	RQD%
1	0,6	995.1	Topsoil with silty-clays						100	
			Firmly plastic silty-clays				pebble and gravel (25%)			
2			Firmly plastic silty-clays				pebble and gravel (25%)			
3	2,8	992.9	Firmly plastic silty-clays				pebble and gravel (25%)		90	
4			Pebble and gravel (with a size of 0,2-0,8 m)				sand and silty-sand (20%)			
5			Pebble and gravel (with a size of 0,2-0,8 m)				sand and silty-sand (20%)			
6			Pebble and gravel (with a size of 0,2-0,8 m)				sand and silty-sand (20%)			
7			Pebble and gravel (with a size of 0,2-0,8 m)				sand and silty-sand (20%)			
8			Pebble and gravel (with a size of 0,2-0,8 m)				sand and silty-sand (20%)			
9			Pebble and gravel (with a size of 0,2-0,8 m)				sand and silty-sand (20%)			
10			Pebble and gravel (with a size of 0,2-0,8 m)				sand and silty-sand (20%)			
11			Pebble and gravel (with a size of 0,2-0,8 m)				sand and silty-sand (20%)			
12			Pebble and gravel (with a size of 0,2-0,8 m)				sand and silty-sand (20%)			
13			Pebble and gravel (with a size of 0,2-0,8 m)				sand and silty-sand (20%)			
14			Pebble and gravel (with a size of 0,2-0,8 m)				sand and silty-sand (20%)			
15	15.0	980.7	Pebble and gravel (with a size of 0,2-0,8 m)				sand and silty-sand (20%)		90	
			End of borehole							

Table: Borehole 17

BOREHOLE 17 Absolute Elevation 995.6 masl										
Depth, m	Layer bottom depth m	Absolute elevation of layer bottom in m	Description of Rock/Soil	Degree of Weatheredness	Orientation	Roughness	Filling material	Joints/m	Core REC%	RQD%
1	0.4	995.2	Topsoil with silty-clays and detritus						100	
			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of fine-grained sands with a size of 0,2 m			Sands and silty-sands			
2			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of fine-grained sands with a size of 0,2 m			Sands and silty-sands			
3			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of fine-grained sands with a size of 0,2 m			Sands and silty-sands			
4			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of fine-grained sands with a size of 0,2 m			Sands and silty-sands			
5			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of fine-grained sands with a size of 0,2 m			Sands and silty-sands			
6			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of fine-grained sands with a size of 0,2 m			Sands and silty-sands			
7			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of fine-grained sands with a size of 0,2 m			Sands and silty-sands			
8			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of fine-grained sands with a size of 0,2 m			Sands and silty-sands			
9			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of fine-grained sands with a size of 0,2 m			Sands and silty-sands			
10			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of fine-grained sands with a size of 0,2 m			Sands and silty-sands			
11			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of fine-grained sands with a size of 0,2 m			Sands and silty-sands			
12			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of fine-grained sands with a size of 0,2 m			Sands and silty-sands			
13			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of fine-grained sands with a size of 0,2 m			Sands and silty-sands			
14			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of fine-grained sands with a size of 0,2 m			Sands and silty-sands			
15			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of fine-grained sands with a size of 0,2 m			Sands and silty-sands		100	
	15.0	980.6								
			End of borehole							

Table: Borehole 18

BOREHOLE 18 Absolute Elevation 996.25 masl										
Depth, m	Layer bottom depth m	Absolute elevation of layer bottom in m	Description of Rock/Soil	Degree of Weatheredness	Orientation	Roughness	Filling material	Joints/m	Core REC%	RQD%
1	0,3	995.95	Topsoil with silty-sands and detritus							
			Firmly plastic silty-clays				pebble and gravel (20%)			
2	2.4	993.85	Firmly plastic silty-clays						100	
			Pebble and gravle (with a size of 0,2-0,8 m)				sand and silty-sand (25%)			
3			Pebble and gravle (with a size of 0,2-0,8 m)				sand and silty-sand (25%)			
4			Pebble and gravle (with a size of 0,2-0,8 m)				sand and silty-sand (25%)			
5			Pebble and gravle (with a size of 0,2-0,8 m)				sand and silty-sand (25%)			
6			Pebble and gravle (with a size of 0,2-0,8 m)				sand and silty-sand (25%)			
7			Pebble and gravle (with a size of 0,2-0,8 m)				sand and silty-sand (25%)		100	
8	7.2	989.05	Pebble and gravle (with a size of 0,2-0,8 m)				sand and silty-sand (25%)			
			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of sands			sand and silty-sand (25%)			
9			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of sands			sand and silty-sand (25%)			
10			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of sands			sand and silty-sand (25%)			
11			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of sands			sand and silty-sand (25%)			
12			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of sands			sand and silty-sand (25%)			
13			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of sands			sand and silty-sand (25%)			
14			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of sands			sand and silty-sand (25%)			
15			Pebble and gravel (with a size of 0,2-0,3 m)	Thin layers of sands			sand and silty-sand (25%)			
	15.0	981.8							95	
			End of borehole							

Table: Borehole 20

BOREHOLE 20 Absolute Elevation 1243.8 masl										
Depth, m	Layer bottom depth m	Absolute elevation of layer bottom in m	Description of Rock/Soil	Degree of Weatheredness	Orientation	Roughness	Filling material	Joints/m	Core REC%	RQD%
1	0,3	1241.6	Topsoil with silty-clays						100	
			Boulders of basalts				silty sand (20%)			
2	1.6	1240.3	Boulders of basalts				silty sand (20%)		50	
			Compact and rarely porous basalts		Horizontal	R		1	100	100
3			Compact and rarely porous basalts		Horizontal	R		4	100	90
4			Compact and rarely porous basalts		Horizontal	R		2	80	80
5	4.3	1237.6	Compact and rarely porous basalts		Horizontal	R		1	100	100
			Porous and cavernous basalts		Horizontal	R		6	90	70
6			Porous and cavernous basalts		Horizontal	R		9	90	60
7			Porous and cavernous basalts		Horizontal	R		2	80	80
8			Porous and cavernous basalts		Horizontal	R		5	80	75
9	8.8	1233.1	Porous and cavernous basalts		Horizontal	R		6	60	30
10			Boulders, detritus and gruss from porous basalts with volcanic ashes				Sands (mainly washed out)	sand		
11	10.5	1231.4	Boulders, detritus and gruss from porous basalts with volcanic ashes				Sands (mainly washed out)		60	
								1	90	90
12			Porous basalts. In final interval the basalts are compact, porous and fractured		Horizontal	R		3	90	80
13			Porous basalts. In final interval the basalts are compact, porous and fractured		Horizontal	R		3	85	85
14			Porous basalts. In final interval the basalts are compact, porous and fractured		Horizontal	R		3	50	50
15	15.5	1226.9	Porous basalts. In final interval the basalts are compact, porous and fractured		Horizontal	R		2	50	40
			End of borehole							

Table: Borehole 21

BOREHOLE 21 Absolute Elevation 1243.8 masl										
Depth, m	Layer bottom depth m	Absolute elevation of layer bottom in m	Description of Rock/Soil	Degree of Weatheredness	Orientation	Roughness	Filling material	Joints/m	Core REC%	RQD%
1	0,4	1243.4	Topsoil with silty-clays							
			Pebble and gravel					Sand filling 25%		
2			Pebble and gravel					Sand filling 25%		
3			Pebble and gravel					Sand filling 25%		
4			Pebble and gravel					Sand filling 25%	100	
	4,0	1239,8								
5			Fractured basalt, rarely porous		Horizontal	R		14	95	10
6			Fractured basalt, rarely porous		Horizontal	R		7	70	20
7	6,5	1237,3	Fractured basalt, rarely porous		Horizontal	R		3	100	60
	7	1236,8	Boulders and detritus of porous basalts (volcanic ashes)				Sand (washed out)		70	
8			Fractured basalt, rarely porous		Horizontal	R		9	80	50
9	8,5	1235,3	Fractured basalt, rarely porous		Horizontal	R		2	60	60
10										
11										
12										
13										
14										
15			Core lost							

Layouts and Geological-Lithological Cross Sections

Plan-view and geological-lithological sections along weirsite of Gargar SHPP

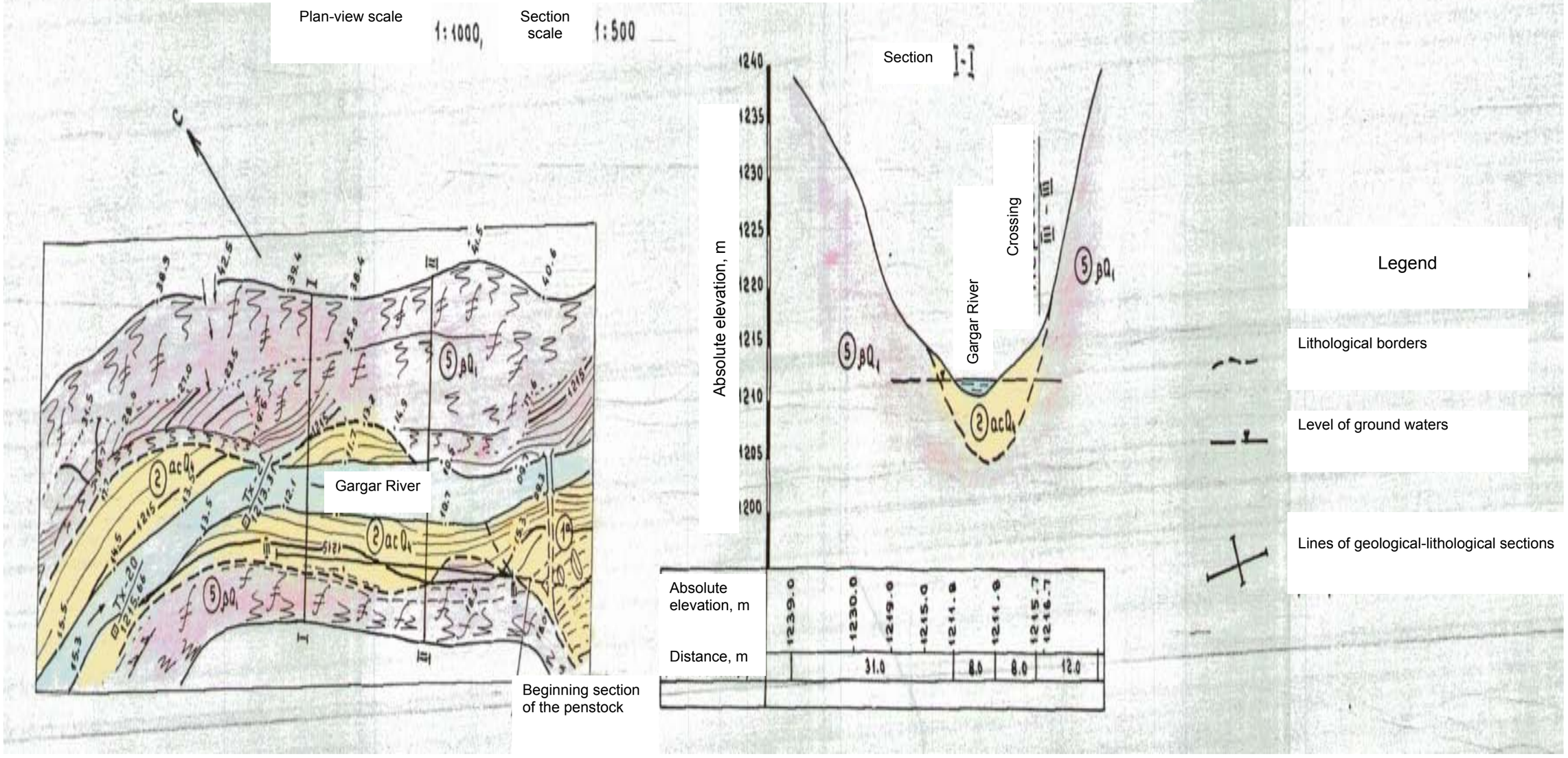
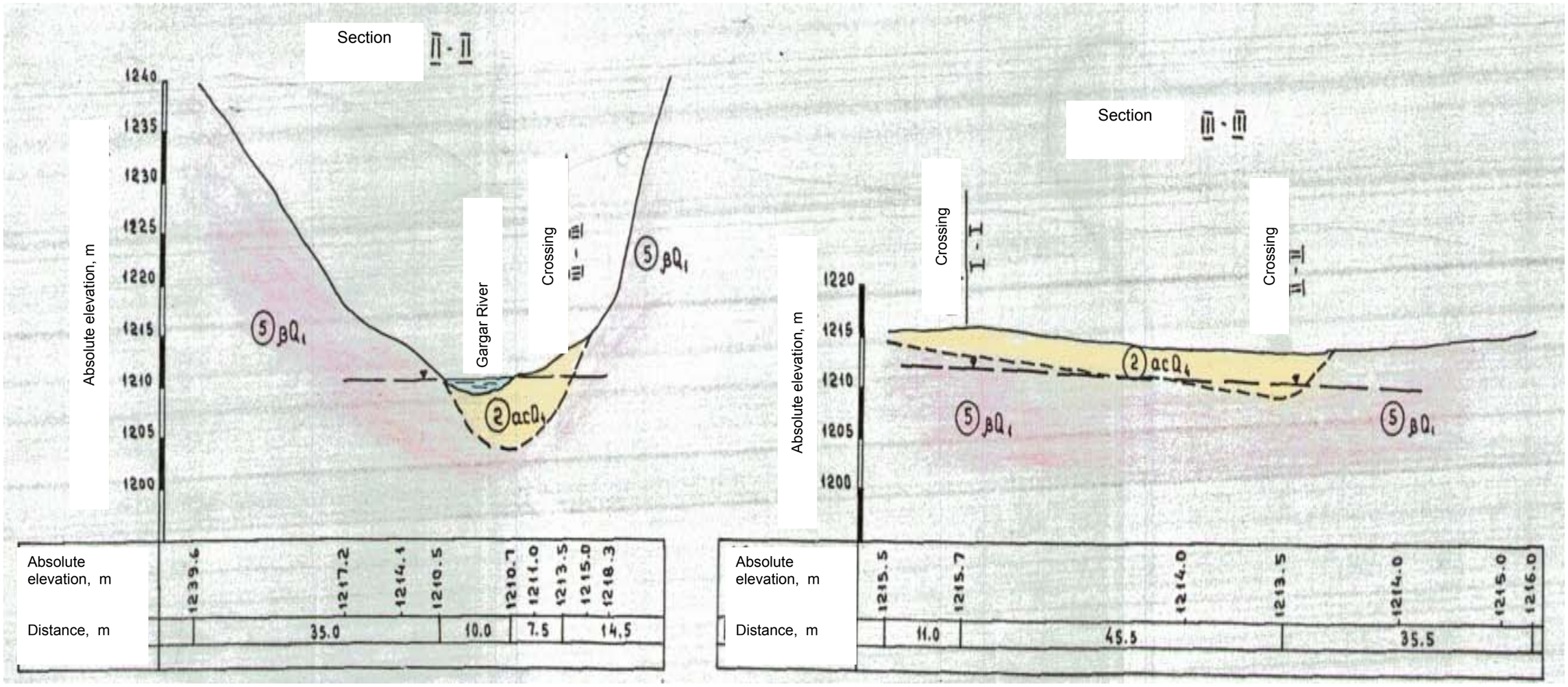


Figure: Plan and Longitudinal View of the Weirsite of Gargar SHPP



For legend please refer to previous figure

Figure: Longitudinal View of the Weirsite of Gargar SHPP

Geological map and geological-lithological section along penstock alignment of Gargar SHPP

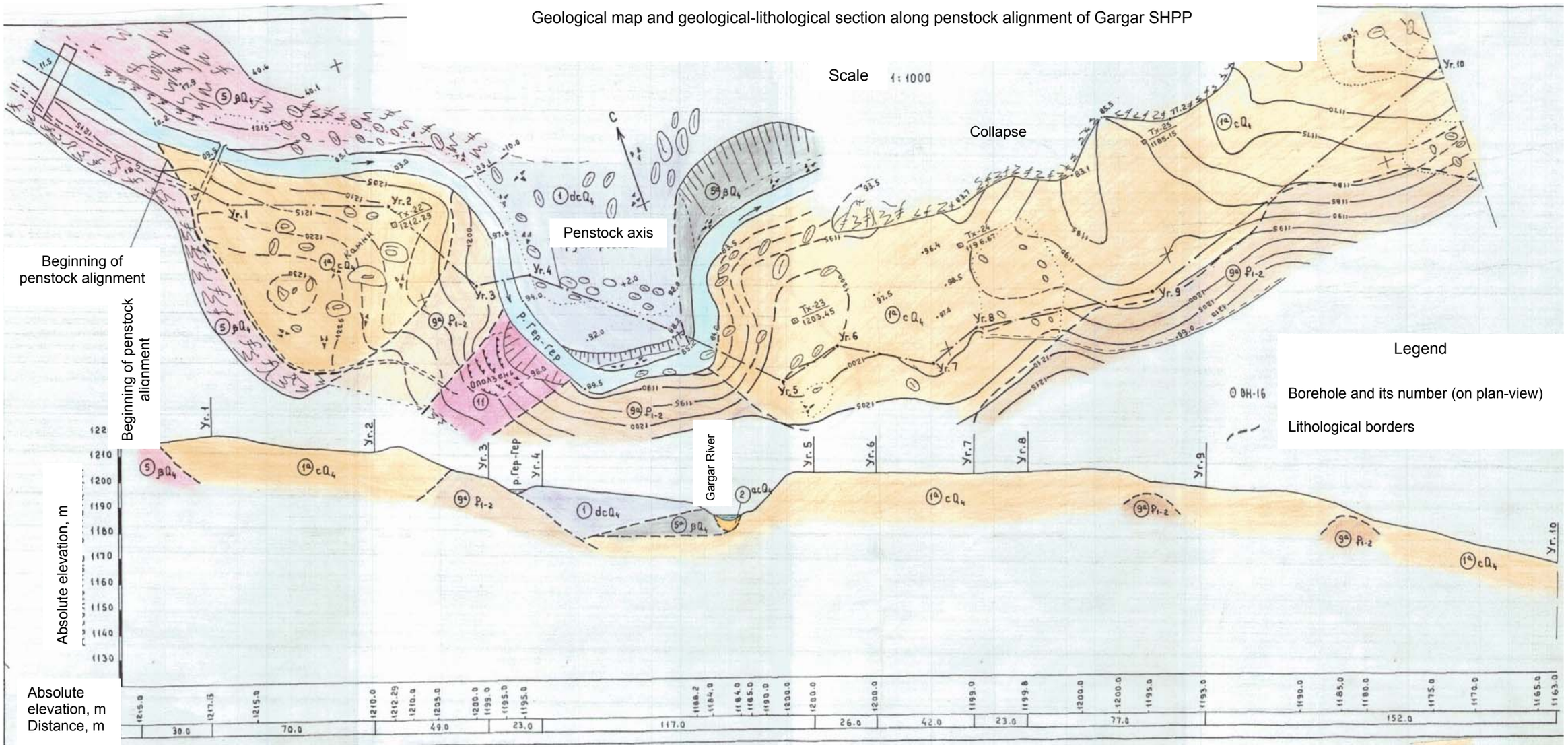
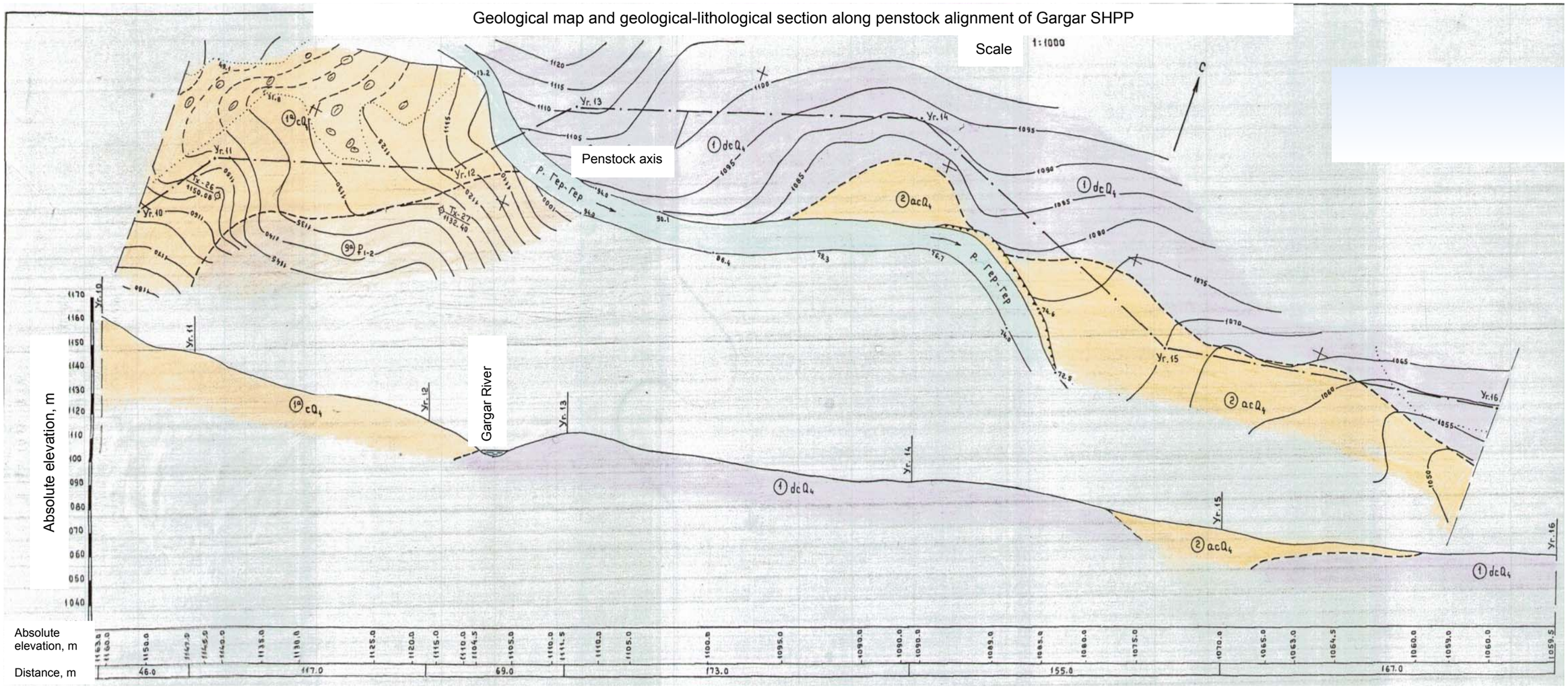


Figure: Plan and Longitudinal View of the Waterway of Gargar SHPP

Geological map and geological-lithological section along penstock alignment of Gargar SHPP



For legend please refer to previous figure

Figure: Plan and Longitudinal View of the Waterway of Gargar SHPP

Geological map and geological-lithological section along penstock alignment of Gargar SHPP

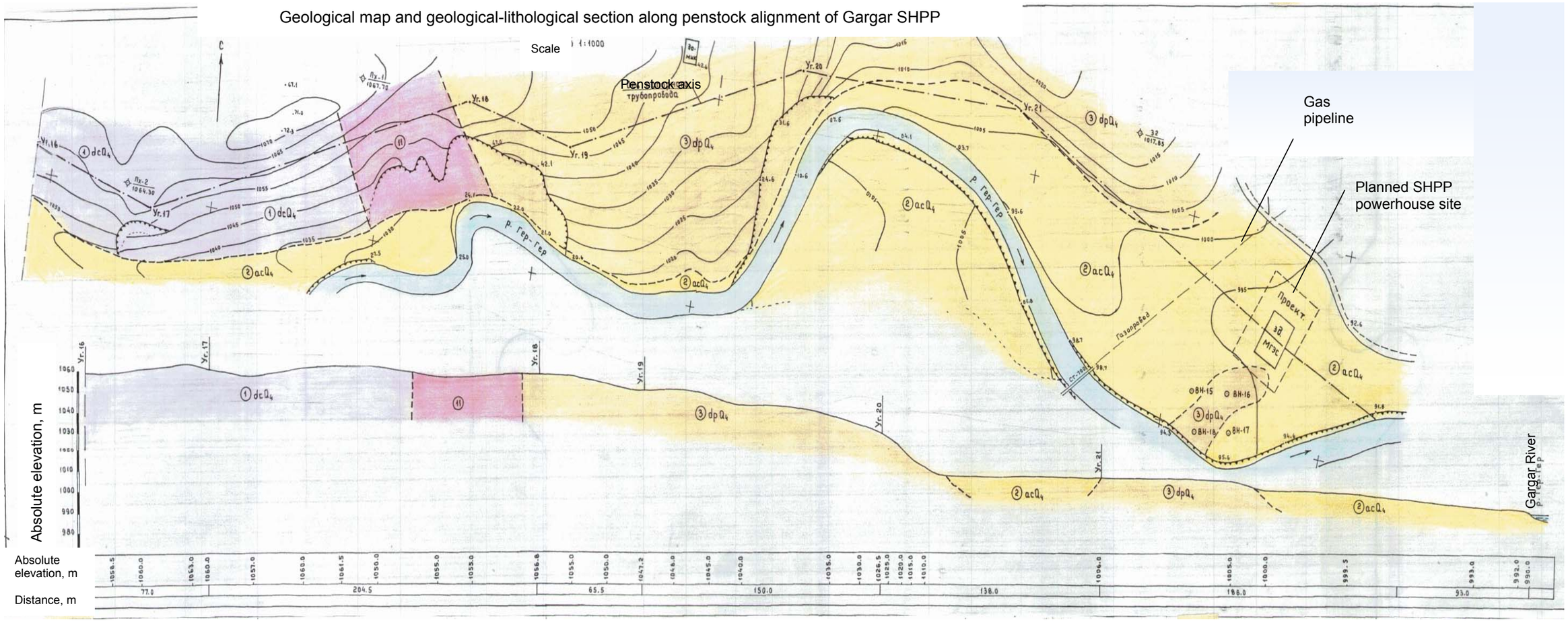


Figure: Plan and Longitudinal View of the Waterway of Gargar SHPP

Chemical Composition

Table: Results of chemical analysis of the underground waters of Gargar SHPP

No	Water sample selection date	Water sample selection site	The depth of the water sample selection m	Dry sediment mg/l	Milligrammes for 1 litre of water										Milligrammes-equivalents							
					Na'+K'	Ca"	Mg"	Er'	Cl'	SO_4"	HCO_3'	CO_3"	Er'	Er'+r'	Na'+K'	Ca"	Mg"	Cl'	SO_4"	HCO_3'	CO_3"	E
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	14.05.04	Gargar River		159,1	10,6	34,0	6,1	59,7	14,2	12,0	146,4	n/a	172,6	232,3	0,85	1,70	0,50	0,40	0,25	2,40	n/a	6,10
2	16.06.04	BH-15	5,7	208,0	3,5	50,0	19,4	72,9	7,1	12,0	231,8	n/a	250,9	323,8	0,15	2,50	1,60	0,20	0,25	3,80	n/a	8,5
3	15.06.04	BH-16	5,5	195,3	1,6	52,0	15,8	69,4	14,2	8,0	207,4	n/a	229,6	299,0	0,07	2,60	1,30	0,40	0,17	3,40	n/a	7,94
4	15.06.04	BH-17	3,6	190,6	1,2	52,0	14,6	67,8	7,1	12	207,4	n/a	226,5	294,3	0,05	2,60	1,20	0,20	0,25	3,40	n/a	7,70
5	13.06.04	BH-18	4,7	222,3	5,8	62,0	13,4	81,2	7,1	12,0	244,0	n/a	263,1	344,3	0,25	3,10	1,10	0,20	0,25	4,00	n/a	8,90
6	14.05.04	BH-21	1,2	247,8	15,0	70,0	8,5	93,5	14,2	12,0	256,2	n/a	282,4	375,9	0,65	3,50	0,70	0,40	0,25	4,20	n/a	9,70

No	Water sample selection date	Water sample selection site	The depth of the water sample selection m	Dry sediment mg/l	Milligrammes-equivalents in %							Harshness mg-equiv.			pH	Carbonic acid CO_2,		Water formula according to Kourlov	
					Na'+K'	Ca"	Mg"	Cl'	SO_4"	HCO_3'	CO_3"	gross	removable	permanent		free	corrosive		
1	2	3	4	5	24	25	26	27	28	29	30	31	32	33	34	35	36	37	
1	14.05.04	Gargar River		159,1	13,9	27,9	8,2	6,5	4,2	39,3	n/a	2,2	2,2	n/a	6,4	26,4	n/a	$M_{0,4}$	HCO_3 79; Cl12 Ca56; Na28; Mg16
2	16.06.04	BH-15	5,7	208,0	1,8	29,4	18,8	2,3	3,0	44,7	n/a	4,1	3,8	0,3	6,6	26,4	4,4	$M_{0,21}$	HCO_3 89 Ca57; Mg38
3	15.06.04	BH-16	5,5	195,3	0,9	32,7	16,4	5	2,2	42,8	n/a	3,9	3,4	0,5	6,4	61,6	8,8	$M_{0,21}$	HCO_3 89; Cl10 Ca65; Mg33
4	15.06.04	BH-17	3,6	190,6	0,7	33,7	15,6	2,6	3,3	44,1	n/a	3,8	3,4	0,4	7,0	8,8	4,4	$M_{0,2}$	HCO_3 88 Ca67; Mg31
5	13.06.04	BH-18	4,7	222,3	2,8	34,8	12,4	2,2	2,8	45,0	n/a	4,2	4,0	0,2	6,8	35,2	4,4	$M_{0,22}$	HCO_3 89 Ca70; Mg25
6	14.05.04	BH-21	1,2	247,8	6,8	36,0	7,2	4,1	2,6	43,3	n/a	4,2	4,2	n/a	7	35,2	n/a	$M_{0,25}$	HCO_3 87 Ca72; Na14; Mg14

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Transport and Access Facilities

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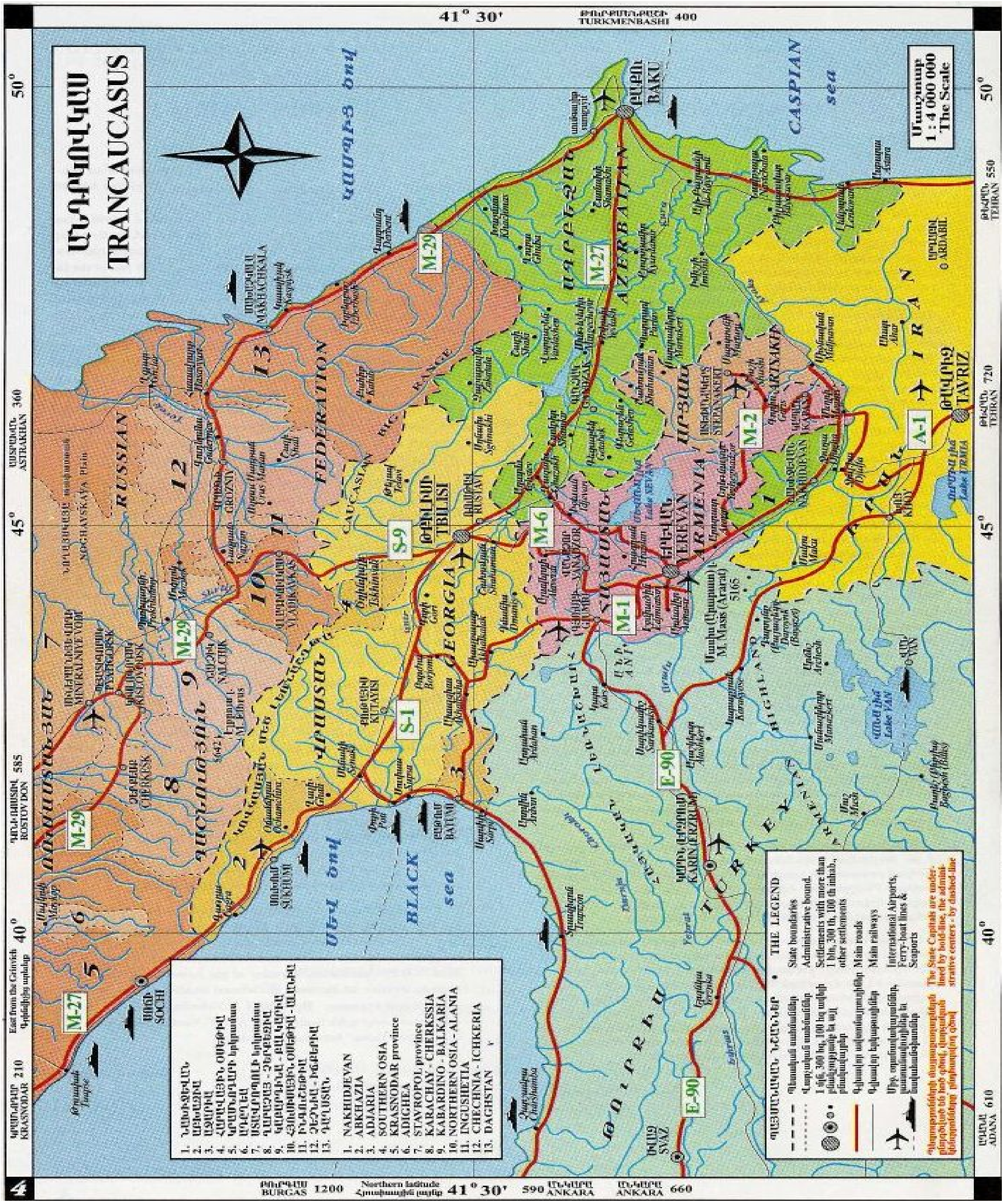

Figure: Trancaucasus Map

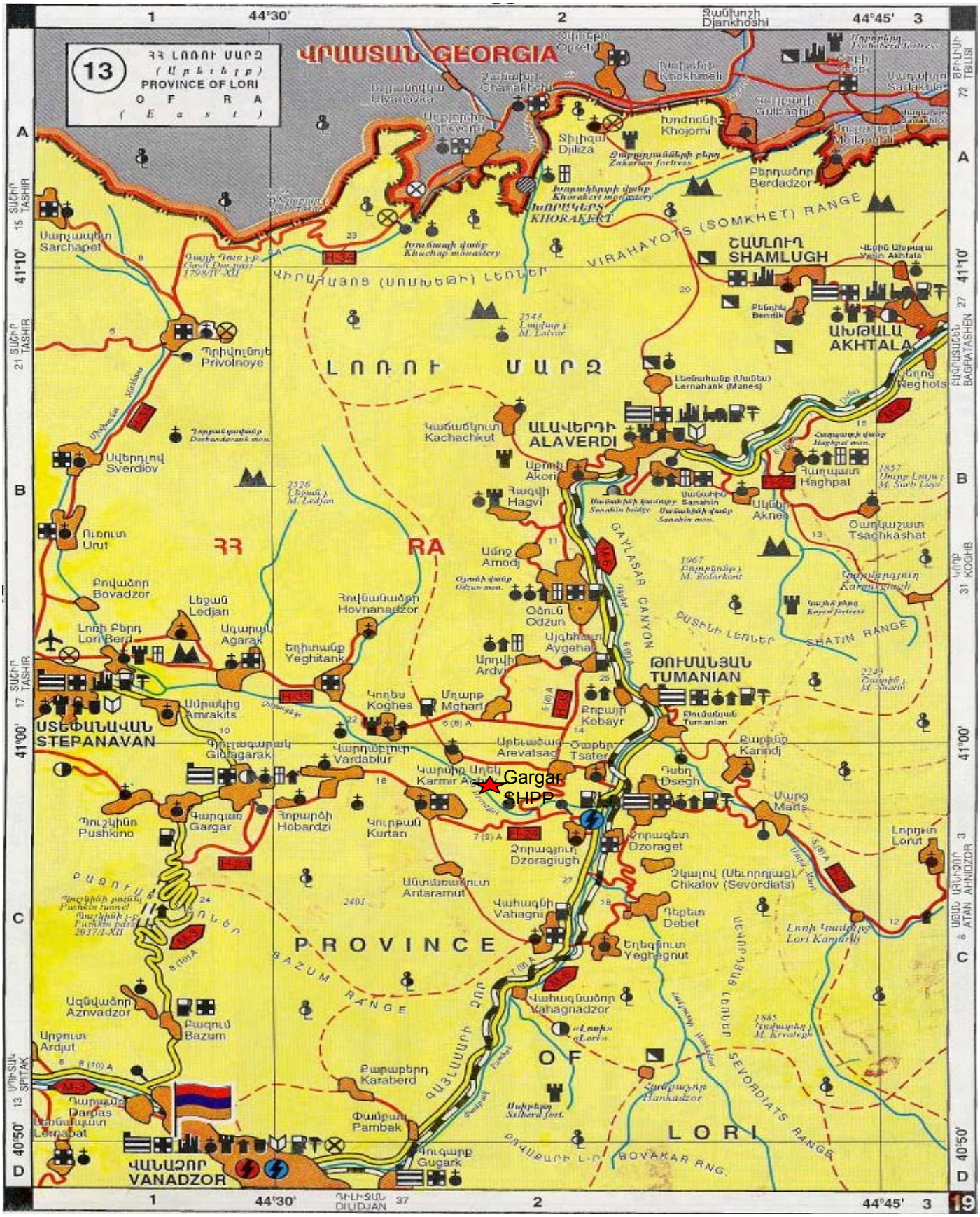

Figure: Lori Region Map

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Description and Evaluation of Layout Alternatives

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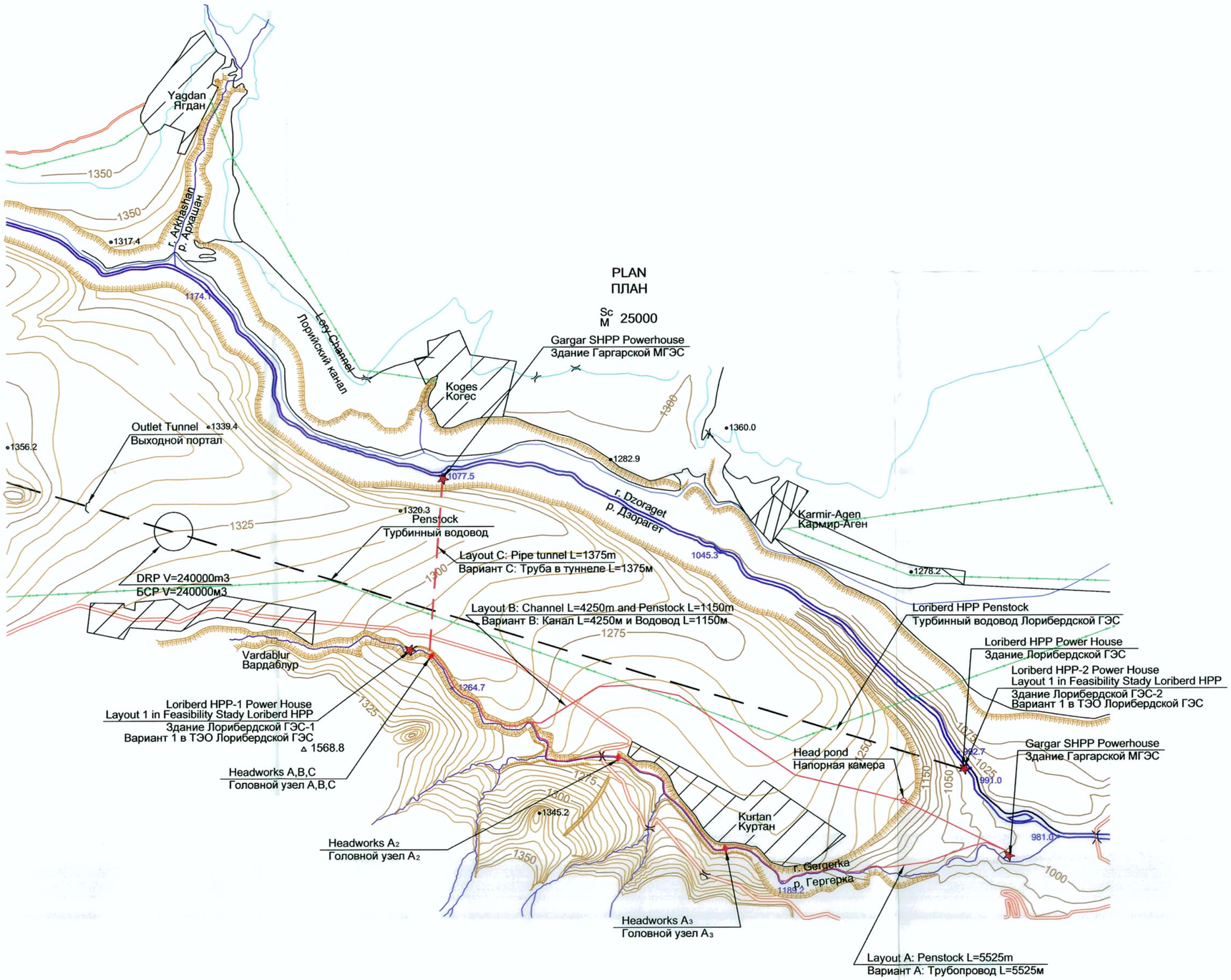
Principle Sketch of Layout Alternatives



FICHTNER YSUAC			EUROPEAN COMMISSION			EuropeAid
			Hydropower Development in Armenia			
	Date	Name	GARGAR HYDROPOWER DEVELOPMENT PROJECT GARGAR SHPP LAYOUT ALTERNATIVES			Scale: 1 : 1
Drawn:	July	Adilkhanyan				Sheet: 1 of 1
Checked:	September	Palt				
Supersedes:						
Superseded by:			Size: A2	Project No.: 5761A25	Document No: 12672434	
System: AutoCAD 2004			Annex: 8	Drawing No.:		BW10A001

Key Data of Layout Alternatives

Table: Key Data of Layout Alternative A

Data for flow calculation at dam site				
Infiltration factor				0.9
Factor for calculation flow at dam site				1.000
Demand, [m^3/s]				
Month	Jan.	Feb.	Mar.	Apr.
Demand	0.01	0.01	0.01	0.01
Month	May	Jun.	Jul.	Aug.
Demand	0.01	0.35	0.35	0.35
Month	Sep.	Oct.	Nov.	Dec.
Demand	0.01	0.01	0.01	0.01
Average flow characteristics at gauging station				
Mean observed discharge,[m^3/s]				1.26
Mean runoff observed, [mln.m^3]				39.80
Mean natural discharge, [m^3/s]				1.30
Mean runoff natural, [mln.m^3]				41.06
Average flow characteristics at dam site				
Mean natural discharge, [m^3/s]				1.30
Mean runoff natural, [mln.m^3]				41.06
Mean remaining discharge, [m^3/s]				1.17
Mean remaining runoff, [mln.m^3]				37.01

Qecolog fixed Armenian norm	
Qecol, [m^3/s]	0.04
German norm	
Q rec. ecol, [m^3/s]	0.20
Q rec. ecol1, [m^3/s]	0.10
Q rec. ecol2, [m^3/s]	0.41
Qecolog variable	
Qrec. ecol, [m^3/s]	0.20
Qecol1, [m^3/s]	0.10
Qecol2, [m^3/s]	0.50
Qecol calc.=0 for German norm	
Qecol calc., [m^3/s]	0.04

Design characteristics					
Design discharge, [m^3/s]	2	Turbine type	Pelton	H_{pelton}, [m]	3
Number of turbine	2	Conduit	Pressure	Free flow	Penstock
Min discharge, [m^3/s]	0.030	Cross-section	Circle	Trapezoidal	Circle
Annual Flow through HPP, [mln m^3]	25.7	Count of conduit	1	1	1
Annual Flow through weir, [mln m^3]	11.3	Filling	-	0.636	-
Length of weir, [m]	10	Width, [m]	-	1.1	-
Discharge coefficient of weir	0.48	Wall slope	-	0	-
Elevation of weir crest, [m]	1275	Diameter/height, [m]	1.2	1.1	1.2
Elevation of river bed at power house, [m]	994	Length, [m]	5475	0	50
Head losses at design discharge, [m]	11.25	Roughness	0.011	0.015	0.011
Max head, [m]	278.0	Head loss at Qd,[m]	10.88	0.00	0.37
Min head, [m]	266.7	Slope piezo/bottom	0.00199	-	0.007456
Efficiency	0.9	Velocity, [m/s]	1.77	2.60	1.77
Power and energy					
Max daily power, [MW]	4.71	Max daily energy, [GWh]			0.11
Min daily power, [MW]	0.00	Min daily energy, [GWh]			0.00
Annual energy, [GWh]	17.12	Potential, [GWh]			28.3
Gross head, [m]	281	Utilization, [%]			60.41
Net head, [m]	266.7	Installed capacity, [MW]			4.71
Plant factor	0.41	Yearly number hour of operation HPP			3634

Table: Key Data of Layout Alternative B

Data for flow calculation at dam site				
Infiltration factor				0.9
Factor for calculation flow at dam site				1.000
Demand, [m^3/s]				
Month	Jan.	Feb.	Mar.	Apr.
Demand	0.01	0.01	0.01	0.01
Month	May	Jun.	Jul.	Aug.
Demand	0.01	0.35	0.35	0.35
Month	Sep.	Oct.	Nov.	Dec.
Demand	0.01	0.01	0.01	0.01
Average flow characteristics at gauging station				
Mean observed discharge,[m^3/s]				1.26
Mean runoff observed, [mln.m^3]				39.80
Mean natural discharge, [m^3/s]				1.30
Mean runoff natural, [mln.m^3]				41.06
Average flow characteristics at dam site				
Mean natural discharge, [m^3/s]				1.30
Mean runoff natural, [mln.m^3]				41.06
Mean remaining discharge, [m^3/s]				1.17
Mean remaining runoff, [mln.m^3]				37.01

Qecolog fixed Armenian norm	
Qecol, [m^3/s]	0.04
German norm	
Q rec. ecol, [m^3/s]	0.20
Q rec. ecol1, [m^3/s]	0.10
Q rec. ecol2, [m^3/s]	0.41
Qecolog variable	
Qrec. ecol, [m^3/s]	0.20
Qecol1, [m^3/s]	0.10
Qecol2, [m^3/s]	0.50
Qecol calc.=0 for German norm	
Qecol calc., [m^3/s]	0.04

Design characteristics					
Design discharge, [m^3/s]	2	Turbine type	Pelton	H_{pelton}, [m]	3
Number of turbine	2	Conduit	Pressure	Free flow	Penstock
Min discharge, [m^3/s]	0.030	Cross-section	Circle	Trapezoidal	Circle
Annual Flow through HPP, [mln m^3]	25.7	Count of conduit	1	1	1
Annual Flow through weir, [mln m^3]	11.3	Filling	-	0.636	-
Length of weir, [m]	10	Width, [m]	-	1.1	-
Discharge coefficient of weir	0.48	Wall slope	-	0	-
Elevation of weir crest, [m]	1275	Diameter/height, [m]	1.2	1.1	1.2
Elevation of river bed at power house, [m]	994	Length, [m]	1100	4275	50
Head losses at design discharge, [m]	34.21	Roughness	0.011	0.015	0.011
Max head, [m]	246.8	Head loss at Qd,[m]	2.64	31.20	0.37
Min head, [m]	243.8	Slope piezo/bottom	0.00240	0.007298	0.007456
Efficiency	0.9	Velocity, [m/s]	1.77	2.60	1.77
Power and energy					
Max daily power, [MW]	4.30	Max daily energy, [GWh]			0.10
Min daily power, [MW]	0.00	Min daily energy, [GWh]			0.00
Annual energy, [GWh]	15.46	Potential, [GWh]			28.3
Gross head, [m]	281	Utilization, [%]			54.56
Net head, [m]	243.8	Installed capacity, [MW]			4.30
Plant factor	0.41	Yearly number hour of operation HPP			3591

Table: Key Data of Layout Alternative C

Data for flow calculation at dam site				
Infiltration factor				0.9
Factor for calculation flow at dam site				1.000
Demand, [m^3/s]				
Month	Jan.	Feb.	Mar.	Apr.
Demand	0.01	0.01	0.01	0.01
Month	May	Jun.	Jul.	Aug.
Demand	0.01	0.35	0.35	0.35
Month	Sep.	Oct.	Nov.	Dec.
Demand	0.01	0.01	0.01	0.01
Average flow characteristics at gauging station				
Mean observed discharge,[m^3/s]				1.26
Mean runoff observed, [mln.m^3]				39.80
Mean natural discharge, [m^3/s]				1.30
Mean runoff natural, [mln.m^3]				41.06
Average flow characteristics at dam site				
Mean natural discharge, [m^3/s]				1.30
Mean runoff natural, [mln.m^3]				41.06
Mean remaining discharge, [m^3/s]				1.17
Mean remaining runoff, [mln.m^3]				37.01

Qecolog fixed Armenian norm	
Qecol, [m^3/s]	0.04
German norm	
Q rec. ecol, [m^3/s]	0.20
Q rec. ecol1, [m^3/s]	0.10
Q rec. ecol2, [m^3/s]	0.41
Qecolog variable	
Qrec. ecol, [m^3/s]	0.20
Qecol1, [m^3/s]	0.10
Qecol2, [m^3/s]	0.50
Qecol calc.=0 for German norm	
Qecol calc., [m^3/s]	0.04

Design characteristics					
Design discharge, [m^3/s]	2	Turbine type	Pelton	H_{pelton}, [m]	3
Number of turbine	2	Conduit	Pressure	Free flow	Penstock
Min discharge, [m^3/s]	0.030	Cross-section	Circle	Trapezoidal	Circle
Annual Flow through HPP, [mln m^3]	25.7	Count of conduit	1	1	1
Annual Flow through weir, [mln m^3]	11.3	Filling	-	0.636	-
Length of weir, [m]	10	Width, [m]	-	1.1	-
Discharge coefficient of weir	0.48	Wall slope	-	0	-
Elevation of weir crest, [m]	1275	Diameter/height, [m]	1.2	1.1	1.2
Elevation of river bed at power house, [m]	1077.5	Length, [m]	1325	0	50
Head losses at design discharge, [m]	3.43	Roughness	0.011	0.015	0.011
Max head, [m]	194.5	Head loss at Qd,[m]	3.06	0.00	0.37
Min head, [m]	191.1	Slope piezo/bottom	0.00231	-	0.007456
Efficiency	0.9	Velocity, [m/s]	1.77	2.60	1.77
Power and energy					
Max daily power, [MW]	3.37	Max daily energy, [GWh]			0.08
Min daily power, [MW]	0.00	Min daily energy, [GWh]			0.00
Annual energy, [GWh]	12.15	Potential, [GWh]			19.9
Gross head, [m]	197.5	Utilization, [%]			60.98
Net head, [m]	191.1	Installed capacity, [MW]			3.37
Plant factor	0.41	Yearly number hour of operation HPP			3600

Quantities and Costs of Waterway

Table: Main Quantities of Waterway for Layout A, B and C

Layout	A	B			C
		Pressure	Free flow	Total	
Pipe thickness, [mm]	14	14	-	-	14
Trench width, [m]	2.2	2.2	2.9	-	4
Trench height, [m]	2.4	2.4	5.1	-	4.4
Wall slope	1	1	1	-	-
Steel pipe, [t]	2289	476	-	476	570
Trench Excavation, [m^3]	60996	10035	163567	173603	21839
Bed material, [m^3]	2431	400	2465	2865	1100
Ferro Concrete, [m^3]	-	-	10200	10200	2200
Backfill, [m^2]	54747	9007	148225	157232	-
Land, [m^2]	-	-	85000	85000	-

Table: Costs of Waterway for Layout A, B and C

Layout	Unit cost for A & B, [$US]	Unit cost for C, [$US]	A	B			C
				Pressure	Free flow	Total	
Steel pipe, [t]	1200	1200	2746897	571752	-	571752	683617
Trench Excavation, [m^3]	10	75	609960	100354	1635672	1736026	1637953
Bed material, [m^3]	15	15	36465	5999	36975	42974	16500
Ferro Concrete, [m^3]	80	250	-	-	816000	816000	550000
Backfill, [m^2]	2	2	109495	18015	296449	314464	-
Land, [m^2]	4.63	4.63	-	-	393519	393519	-
Total			3502817	696120	3178615	3874735	2888070

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Optimization of Design

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Key Data of Layout Alternatives A_2, A_3

Table: Key Data of Layout Alternative A_2

Data for flow calculation at dam site				
Infiltration factor				0.9
Factor for calculation flow at dam site				1.000
Demand, [m^3/s]				
Month	Jan.	Feb.	Mar.	Apr.
Demand	0.01	0.01	0.01	0.01
Month	May	Jun.	Jul.	Aug.
Demand	0.01	0.35	0.35	0.35
Month	Sep.	Oct.	Nov.	Dec.
Demand	0.01	0.01	0.01	0.01
Average flow characteristics at gauging station				
Mean observed discharge,[m^3/s]				1.26
Mean runoff observed, [mln.m^3]				39.80
Mean natural discharge, [m^3/s]				1.30
Mean runoff natural, [mln.m^3]				41.06
Average flow characteristics at dam site				
Mean natural discharge, [m^3/s]				1.30
Mean runoff natural, [mln.m^3]				41.06
Mean remaining discharge, [m^3/s]				1.17
Mean remaining runoff, [mln.m^3]				37.01

Qecolog fixed Armenian norm	
Qecol, [m^3/s]	0.04
German norm	
Q rec. ecol, [m^3/s]	0.20
Q rec. ecol1, [m^3/s]	0.10
Q rec. ecol2, [m^3/s]	0.41
Qecolog variable	
Qrec. ecol, [m^3/s]	0.20
Qecol1, [m^3/s]	0.10
Qecol2, [m^3/s]	0.50
Qecol calc.=0 for German norm	
Qecol calc., [m^3/s]	0.04

Design characteristics					
Design discharge, [m^3/s]	2	Turbine type	Pelton	H_{pelton}, [m]	3
Number of turbine	2	Conduit	Pressure	Free flow	Penstock
Min discharge, [m^3/s]	0.030	Cross-section	Circle	Trapezoidal	Circle
Annual Flow through HPP, [mln m^3]	25.7	Count of conduit	1	1	1
Annual Flow through weir, [mln m^3]	11.3	Filling	-	0.636	-
Length of weir, [m]	10	Width, [m]	-	1.1	-
Discharge coefficient of weir	0.48	Wall slope	-	0	-
Elevation of weir crest, [m]	1243.5	Diameter/height, [m]	1.2	1.1	1.2
Elevation of river bed at power house, [m]	994	Length, [m]	3798	0	50
Head losses at design discharge, [m]	8.09	Roughness	0.011	0.015	0.011
Max head, [m]	246.5	Head loss at Qd,[m]	7.72	0.00	0.37
Min head, [m]	238.4	Slope piezo/bottom	0.00203	-	0.007456
Efficiency	0.9	Velocity, [m/s]	1.77	2.60	1.77
Power and energy					
Max daily power, [MW]	4.21	Max daily energy, [GWh]			0.10
Min daily power, [MW]	0.00	Min daily energy, [GWh]			0.00
Annual energy, [GWh]	15.25	Potential, [GWh]			25.2
Gross head, [m]	249.5	Utilization, [%]			60.61
Net head, [m]	238.4	Installed capacity, [MW]			4.21
Plant factor	0.41	Yearly number hour of operation HPP			3623

Table: Key Data of Layout Alternative A_3

Data for flow calculation at dam site				
Infiltration factor				0.9
Factor for calculation flow at dam site				1.000
Demand, [m^3/s]				
Month	Jan.	Feb.	Mar.	Apr.
Demand	0.01	0.01	0.01	0.01
Month	May	Jun.	Jul.	Aug.
Demand	0.01	0.35	0.35	0.35
Month	Sep.	Oct.	Nov.	Dec.
Demand	0.01	0.01	0.01	0.01
Average flow characteristics at gauging station				
Mean observed discharge,[m^3/s]				1.26
Mean runoff observed, [mln.m^3]				39.80
Mean natural discharge, [m^3/s]				1.30
Mean runoff natural, [mln.m^3]				41.06
Average flow characteristics at dam site				
Mean natural discharge, [m^3/s]				1.30
Mean runoff natural, [mln.m^3]				41.06
Mean remaining discharge, [m^3/s]				1.17
Mean remaining runoff, [mln.m^3]				37.01

Qecolog fixed Armenian norm	
Qecol, [m^3/s]	0.04
German norm	
Q rec. ecol, [m^3/s]	0.20
Q rec. ecol1, [m^3/s]	0.10
Q rec. ecol2, [m^3/s]	0.41
Qecolog variable	
Qrec. ecol, [m^3/s]	0.20
Qecol1, [m^3/s]	0.10
Qecol2, [m^3/s]	0.50
Qecol calc.=0 for German norm	
Qecol calc., [m^3/s]	0.04

Design characteristics					
Design discharge, [m^3/s]	2	Turbine type	Pelton	H_{pelton}, [m]	3
Number of turbine	2	Conduit	Pressure	Free flow	Penstock
Min discharge, [m^3/s]	0.030	Cross-section	Circle	Trapezoidal	Circle
Annual Flow through HPP, [mln m^3]	25.7	Count of conduit	1	1	1
Annual Flow through weir, [mln m^3]	11.3	Filling	-	0.636	-
Length of weir, [m]	10	Width, [m]	-	1.1	-
Discharge coefficient of weir	0.48	Wall slope	-	0	-
Elevation of weir crest, [m]	1215	Diameter/height, [m]	1.2	1.1	1.2
Elevation of river bed at power house, [m]	994	Length, [m]	2347	0	50
Head losses at design discharge, [m]	5.36	Roughness	0.011	0.015	0.011
Max head, [m]	218.0	Head loss at Qd,[m]	4.99	0.00	0.37
Min head, [m]	212.6	Slope piezo/bottom	0.00212	-	0.007456
Efficiency	0.9	Velocity, [m/s]	1.77	2.60	1.77
Power and energy					
Max daily power, [MW]	3.75	Max daily energy, [GWh]			0.09
Min daily power, [MW]	0.00	Min daily energy, [GWh]			0.00
Annual energy, [GWh]	13.56	Potential, [GWh]			22.3
Gross head, [m]	221	Utilization, [%]			60.82
Net head, [m]	212.6	Installed capacity, [MW]			3.75
Plant factor	0.41	Yearly number hour of operation HPP			3610

Quantities and Costs of Waterway for Layouts A, A_2 and A_3

Table: Main Quantities of Waterway for Layouts A, A_2, A_3

Layout	A	A_2	A_3
Pipe thickness, [mm]	14	14	14
Trench width, [m]	2.2	2.2	2.2
Trench height, [m]	2.4	2.4	2.4
Wall slope	1	1	1
Steel pipe, [t]	2289	1594	993
Excavation, [m^3]	60996	42482	26463
Bed material, [m^3]	2431	1693	1055
Backfill, [m^2]	54747	38130	23752

Table: Costs of Waterway for Layouts A, A_2, A_3

Layout	Unit cost, [$US]	A	A_2	A_3
Steel pipe, [t]	1200	2746897	1913133	1191731
Excavation, [m^3]	10	609960	424819	264629
Bed material, [m^3]	15	36465	25397	15820
Backfill, [m^2]	2	109495	76260	47504
Total		3502817	2439609	1519683

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Power and Energy Potential

Table of Content

Water Demand for Irrigation

Table: Irrigation water Demand upstream of Gargar SHPP weir site

	Stream name	Channels name	Irrigation area, [hectar]	Unit	Water demands by months					Total annual demands, th.cube. m
					May	June	July	Aug	Sep	
1	Dubrovaya balka (Gargar river tributary)	Dubrovaya balka	58	L/s	-	22	22	22	-	
				Th.m^3	-	57	59	59	-	175
2	Pushkino (Gargar river tributary/stream)	Village stream	114	L/s	-	43	43	43	-	
				Th.m^3	-	111	115	115	-	341
3	Dvaly gorge (Gargar river stream)	Dvaly gorge river	67	L/s	-	25	25	25	-	
				Th.m^3	-	65	68	68	-	201
4	Gargar river	Kurtun channel	530	L/s	-	200	200	200	-	
				Th.m^3	-	519	536	536	-	1591
5	Gargar river	Gardens stream	26	L/s	-	10	10	10	-	
				Th.m^3	-	26	26	27	-	80
6	Gargar river	Chlkan stream	53	L/s	-	20	20	20	-	
				Th.m^3	-	51	53	53	-	157
7	Gargar river	Gardens stream	67	L/s	-	25	25	25	-	
				Th.m^3	-	65	68	68	-	201
Total			915	L/s	-	345	345	345	-	
				Th.m^3	-	894	926	926	-	2746

Minimum Ecological Flow

Table: Flow Duration Curve for Determination of Minimum Ecological Flow

#	Year	Min low flow NNQ [m3/s]	%
1	1992	1.79	2.27
2	1996	0.42	4.55
3	1997	0.40	6.82
4	1991	0.38	9.09
5	1998	0.38	11.36
6	1968	0.35	13.64
7	1988	0.35	15.91
8	1999	0.33	18.18
9	1994	0.31	20.45
10	1995	0.29	22.73
11	1976	0.25	25.00
12	1990	0.25	27.27
13	1973	0.24	29.55
14	1982	0.24	31.82
15	1989	0.23	34.09
16	1987	0.22	36.36
17	1981	0.21	38.64
18	1964	0.20	40.91
19	1993	0.19	43.18
20	1967	0.18	45.45
21	1986	0.17	47.73
22	1983	0.16	50.00
23	1984	0.16	52.27
24	2000	0.16	54.55
25	2001	0.16	56.82
26	1966	0.15	59.09
27	1979	0.15	61.36
28	1985	0.15	63.64
29	1960	0.14	65.91
30	1975	0.13	68.18
31	1980	0.13	70.45
32	1963	0.12	72.73
33	1961	0.10	75.00
34	1972	0.10	77.27
35	1959	0.09	79.55
36	1977	0.09	81.82
37	1978	0.08	84.09
38	1970	0.07	86.36
39	1962	0.05	88.64
40	1965	0.05	90.91
41	1971	0.05	93.18
42	1974	0.05	95.45
43	1958	0.02	97.73

Calculation of Headlosses

Table: Head Losses

Structure and species of losses	Data		Q	Width	Height	Diame-ter	Length	Rough-ness	Area	Velocity	Coeffi-cient	Coeffi-cient	Losses
			[m3/s]	[m]	[m]	[m]	[m]		[m2]	[m/s]		[-]	[m]
Intake													**0.231**
Sand trap	R	0.714	1.8	4	2.5	-	35	0.017	10.0	0.18	55.6	-	0.001
Entrance	-	-	1.8	4	2.5	-	-	-	10	0.18	-	0.5	0.001
Gate slots	**Count**	2	1.8	1.5	1	-	-	-	1.5	1.20	-	0.25	0.037
	α	Space between bars.[m]				Thickness of barsíÿ					Shape Factor		
Intake gate	75	0.01	1.8	1.5	1.5	0.02	-	-	2.25	0.80	2.42	5.89	0.192
Change Cross Section Area	-	-	1.8	4	2.5	-	-	-	10.0	0.18	0.61	0.402	0.001
	-	-	1.8	-		1	-	-	1.13	2.48	-	-	-
Diversion pressure conduit													**8.80**
Friction Losses	-	-	1.8	-	-	1	2070	0.011	0.79	2.29	72.15	0.0151	8.35
Local Losses	α	**Count**	-	-	-	-	-	-	-	-	-	-	-
x Bends 20°	20	1	1.8	-	-	1	-	-	0.79	2.29	0.143	0.049	0.013
x Bends 25°	25	5	1.8	-	-	1	-	-	0.79	2.29	0.143	0.061	0.081
x Bends 30°	30	4	1.8	-	-	1	-	-	0.79	2.29	0.143	0.072	0.077
x Bends 35°	35	3	1.8	-	-	1	-	-	0.79	2.29	0.143	0.082	0.066
x Bends 40°	40	5	1.8	-	-	1	-	-	0.79	2.29	0.143	0.092	0.123
x Bends 40°	45	1	1.8	-	-	1	-	-	0.79	2.29	0.143	0.101	0.027
x Bends 50°	50	1	1.8	-	-	1	-	-	0.79	2.29	0.143	0.110	0.029
x Bends 60°	55	1	1.8	-	-	1	-	-	0.79	2.29	0.143	0.117	0.031
Penstock													**0.378**
Friction Losses	-	-	1.8	-	-	1	50	0.011	0.79	2.29	72.15	0.0151	0.20
Friction Losses in one branch	-	-	1.8	-	-	0.7	6.5	0.011	0.38	4.68	67.99	0.0170	0.176
Valve	-	-	1.8	-	-	0.7	-	-	0.38	4.68	-	0.1	**0.111**
Total Head losses:													**9.52**

Power and Energy Calculations

Table: Results of Power and Energy Potential Calculations

Data for flow calculation at dam site				
Infiltration factor				0.9
Factor for calculation flow at dam site				1.000
Demand, [m^3/s]				
Month	Jan.	Feb.	Mar.	Apr.
Demand	0.008	0.008	0.008	0.008
Month	May	Jun.	Jul.	Aug.
Demand	0.008	0.353	0.353	0.353
Month	Sep.	Oct.	Nov.	Dec.
Demand	0.008	0.008	0.008	0.008
Average flow characteristics at gauging station				
Mean observed discharge,[m^3/s]				1.26
Mean runoff observed, [mln.m^3]				39.80
Mean natural discharge, [m^3/s]				1.30
Mean runoff natural, [mln.m^3]				41.06
Average flow characteristics at dam site				
Mean natural discharge, [m^3/s]				1.30
Mean runoff natural, [mln.m^3]				41.06
Mean remaining discharge, [m^3/s]				1.17
Mean remaining runoff, [mln.m^3]				37.01

Qecolog fixed Armenian norm	
Qecol, [m^3/s]	0.04
German norm	
Q rec. ecol, [m^3/s]	0.20
Q rec. ecol1, [m^3/s]	0.10
Q rec. ecol2, [m^3/s]	0.41
Qecolog variable	
Qrec. ecol, [m^3/s]	0.20
Qecol1, [m^3/s]	0.10
Qecol2, [m^3/s]	0.50
Qecol calc.=0 for German norm	
Qecol calc., [m^3/s]	0.04

Design characteristics					
Design discharge, [m^3/s]	1.8	Turbine type	Pelton	H_{pelton}, [m]	3.9
Number of turbine	2	Conduit	Pressure	Free flow	Penstock
Min discharge, [m^3/s]	0.045	Cross-section	Circle	Trapezoidal	Circle
Annual Flow through HPP, [mln m^3]	24.5	Count of conduit	1	1	1
Annual Flow through weir, [mln m^3]	12.5	Filling	-	0.636	-
Length of weir, [m]	10	Width, [m]	-	1.1	-
Discharge coefficient of weir	1000000	Wall slope	-	0	-
Elevation of weir crest, [m]	1213	Diameter/height, [m]	1	1.1	1
Elevation of river bed at power house, [m]	989.6	Length, [m]	2110	0	50
Head losses at design discharge, [m]	9.68	Roughness	0.011	0.015	0.011
Max head, [m]	219.50	Head loss at Qd,[m]	9.31	0.00	0.38
Min head, [m]	209.82	Slope piezo/bottom	0.00441	-	0.007551
Efficiency	0.85	Velocity, [m/s]	2.29	2.34	2.29
Power and energy					
Max daily power, [MW]	3.16	Max daily energy, [GWh]			0.08
Min daily power, [MW]	0.00	Min daily energy, [GWh]			0.00
Annual energy, [GWh]	12.19	Potential, [GWh]			22.5
Gross head, [m]	223.4	Utilization, [%]			54.10
Net head, [m]	209.8	Installed capacity, [MW]			3.16
Plant factor	0.44	Yearly number hour of operation HPP			3853

Table: Mean Monthly Energy [MWh]

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Yearly
1958	58.5	106.9	232.3	1396.1	1222.0	1053.0	73.5	153.4	526.6	568.0	266.9	301.3	5958.6
1959	142.0	125.0	440.8	2091.8	2355.2	1809.1	2348.4	1564.5	1159.0	1644.4	1446.0	995.7	16122.0
1960	597.6	952.1	867.1	2116.5	1570.0	1913.0	984.8	184.0	476.4	614.6	346.6	349.1	10971.7
1961	173.3	201.7	345.7	1064.6	834.8	199.4	919.9	25.9	251.0	266.3	248.5	299.3	4830.4
1962	337.2	295.5	815.9	1982.9	1711.3	491.1	147.5	0.0	283.2	118.6	249.0	207.1	6639.1
1963	233.4	211.1	538.2	2134.0	2355.2	2190.4	1901.0	1456.9	986.1	1296.9	1456.2	1001.6	15761.0
1964	788.2	524.0	1384.1	2209.7	2355.2	1387.9	1017.5	742.1	880.0	523.6	321.5	416.9	12550.7
1965	257.6	391.9	1199.0	1783.6	1716.7	1116.9	832.1	138.8	279.4	1543.8	816.3	650.4	10726.5
1966	399.8	380.9	751.7	1916.9	2347.4	997.6	727.6	0.0	531.5	661.6	325.9	246.5	9287.4
1967	269.5	210.2	486.2	1942.1	2351.9	1212.1	1888.8	1060.2	1500.8	782.5	1025.3	651.3	13381.0
1968	715.2	908.2	2089.7	2279.3	2355.2	2279.3	1512.8	642.1	786.4	590.9	569.0	661.6	15389.6
1970	350.7	365.4	1334.6	1768.7	1191.3	40.0	62.0	447.9	867.7	388.5	251.5	271.0	7339.2
1971	547.2	288.2	884.3	2011.5	2200.4	1113.2	0.0	0.0	184.4	380.2	215.8	399.5	8224.7
1972	262.0	349.8	913.7	2279.3	2351.4	2245.5	1035.0	511.5	992.9	613.3	437.9	390.2	12382.6
1973	393.9	547.1	629.2	2197.2	1867.0	1860.9	1386.2	254.1	492.2	465.2	742.7	395.1	11230.8
1974	223.3	291.6	1387.9	2114.1	2345.4	1270.1	398.9	782.8	1897.6	710.8	435.7	473.1	12331.3
1975	455.1	349.5	1172.1	2188.8	2319.4	1426.3	359.0	87.9	395.1	1359.1	541.5	383.9	11037.6
1976	587.5	459.9	972.9	2279.3	2355.2	2199.9	1793.3	351.2	692.9	584.2	399.3	400.3	13076.0
1977	372.2	435.6	704.3	1771.6	2290.5	1015.6	606.6	42.5	919.6	882.5	523.8	355.4	9920.4
1978	349.3	844.5	1719.0	2279.3	2355.2	2169.6	721.2	636.5	678.8	554.3	438.9	355.0	13101.6
1979	300.0	298.5	819.8	2054.8	2102.8	2224.3	1656.8	162.3	377.8	626.3	974.8	469.1	12067.3
1980	378.2	345.3	1040.9	2240.9	2020.7	113.8	12.0	68.2	307.0	339.2	265.1	274.3	7405.7
1981	374.7	391.1	500.7	1389.1	2317.7	1479.4	1093.3	1002.6	647.3	576.8	545.2	353.5	10671.4
1982	305.6	312.8	598.7	2235.7	2352.3	1532.5	1008.4	760.0	535.5	608.0	527.0	508.2	11284.8
1983	374.7	281.2	844.5	2082.2	2326.0	1706.9	1027.8	340.1	818.1	684.3	1312.1	951.3	12749.1
1984	288.4	332.6	1245.3	2279.3	2338.4	1488.6	557.0	175.4	528.2	388.9	772.7	427.1	10821.9
1985	273.0	366.9	991.1	2252.8	2144.4	1531.7	520.6	102.9	333.2	403.5	378.3	344.2	9642.6
1986	548.7	241.3	687.8	2227.8	2350.4	2279.3	843.4	157.8	358.2	480.1	751.8	388.7	11315.3
1987	620.3	771.0	1014.8	2200.6	2172.4	1248.9	28.6	306.8	561.9	734.6	1500.6	990.1	12150.6
1988	665.3	535.7	1696.4	2279.3	2355.2	2247.0	2058.1	2182.0	1456.1	1698.5	1399.1	1079.2	19652.1
1989	839.2	744.6	1293.6	1776.6	874.1	367.6	559.0	50.4	449.0	1076.4	1391.8	1526.4	10948.9
1990	590.9	780.9	2006.0	2279.3	2355.2	759.9	126.2	454.9	820.7	896.7	1336.9	877.1	13284.7
1991	949.3	867.5	1643.3	2279.3	2034.4	1094.2	280.7	192.1	518.7	517.4	633.0	585.8	11595.5
1992	2294.9	2171.1	2355.2	2279.3	2355.2	2279.3	2349.1	2348.5	2279.3	2355.2	2279.3	2355.2	27701.5
1993	864.9	795.6	1510.1	2279.3	2355.2	1699.6	538.6	534.7	767.1	686.0	812.2	981.8	13825.1
1994	745.9	986.7	1299.7	2214.7	2001.4	970.7	632.3	1162.6	696.3	725.1	920.5	1259.1	13615.1
1995	870.8	715.0	1633.5	2278.0	2276.4	1786.4	1380.2	102.3	705.6	1119.5	774.3	705.2	14347.1
1996	641.4	739.3	884.9	2279.3	2355.2	1690.7	578.2	457.3	814.8	918.4	847.5	812.0	13018.8
1997	761.1	794.6	930.8	2279.3	2355.2	1861.8	962.4	816.7	1639.0	1853.4	947.3	1180.2	16382.0
1998	686.3	632.8	1091.6	2246.9	2279.6	1755.2	1076.0	963.3	1284.7	679.3	787.5	1077.2	14560.5
1999	715.1	868.3	1002.3	2266.9	2345.8	2160.6	1015.6	409.5	1177.3	898.2	924.5	861.3	14645.5
2000	819.2	799.2	1250.2	2279.3	2355.2	1436.8	96.5	11.5	315.7	912.6	687.0	939.9	11903.1
2001	799.3	608.7	2177.1	2113.0	2287.2	888.1	131.4	0.0	281.6	403.0	392.3	443.5	10525.1
Mean	540.0	549.3	1102.0	2090.7	2120.0	1455.7	866.2	508.0	754.8	793.7	749.3	665.0	12194.8

Table: Mean Monthly Power [kW]

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1958	78.6	159.1	312.2	1939.0	1642.5	1462.5	98.7	206.2	731.4	763.4	370.7	405.0
1959	190.8	186.0	592.5	2905.2	3165.6	2512.6	3156.4	2102.9	1609.8	2210.2	2008.4	1338.3
1960	803.2	1368.0	1165.4	2939.6	2110.2	2657.0	1323.6	247.3	661.6	826.1	481.4	469.2
1961	232.9	300.1	464.6	1478.6	1122.1	277.0	1236.4	34.8	348.7	358.0	345.1	402.2
1962	453.2	439.7	1096.6	2754.0	2300.1	682.0	198.2	0.0	393.3	159.4	345.8	278.4
1963	313.7	314.2	723.4	2963.9	3165.6	3042.3	2555.1	1958.2	1369.5	1743.2	2022.5	1346.3
1964	1059.4	752.9	1860.4	3069.1	3165.6	1927.6	1367.6	997.5	1222.3	703.7	446.5	560.3
1965	346.2	583.3	1611.5	2477.2	2307.3	1551.3	1118.4	186.5	388.1	2075.0	1133.8	874.1
1966	537.4	566.8	1010.4	2662.4	3155.1	1385.5	978.0	0.0	738.2	889.2	452.6	331.4
1967	362.3	312.9	653.5	2697.4	3161.1	1683.5	2538.7	1425.0	2084.4	1051.8	1424.0	875.5
1968	961.3	1304.9	2808.8	3165.6	3165.6	3165.6	2033.3	863.0	1092.3	794.2	790.3	889.3
1970	471.3	543.7	1793.8	2456.5	1601.2	55.6	83.3	602.0	1205.1	522.2	349.3	364.3
1971	735.4	428.9	1188.5	2793.7	2957.6	1546.1	0.0	0.0	256.2	511.1	299.7	537.0
1972	352.2	502.5	1228.2	3165.6	3160.5	3118.7	1391.2	687.5	1379.1	824.4	608.2	524.5
1973	529.5	814.1	845.7	3051.6	2509.4	2584.6	1863.1	341.6	683.6	625.2	1031.6	531.1
1974	300.2	433.9	1865.5	2936.2	3152.4	1764.0	536.2	1052.1	2635.6	955.4	605.1	635.9
1975	611.7	520.0	1575.5	3040.0	3117.5	1980.9	482.5	118.2	548.7	1826.8	752.0	516.0
1976	789.6	660.8	1307.7	3165.6	3165.6	3055.5	2410.3	472.1	962.4	785.1	554.6	538.0
1977	500.3	648.3	946.7	2460.6	3078.6	1410.6	815.4	57.2	1277.2	1186.2	727.5	477.7
1978	469.5	1256.7	2310.4	3165.6	3165.6	3013.4	969.3	855.5	942.7	745.1	609.5	477.2
1979	403.3	444.2	1101.9	2853.9	2826.3	3089.3	2226.9	218.1	524.7	841.9	1353.9	630.5
1980	508.4	496.2	1399.1	3112.4	2715.9	158.1	16.2	91.6	426.3	456.0	368.2	368.7
1981	503.6	582.0	672.9	1929.4	3115.2	2054.7	1469.5	1347.5	899.0	775.2	757.2	475.2
1982	410.8	465.5	804.7	3105.1	3161.7	2128.5	1355.3	1021.5	743.7	817.2	732.0	683.0
1983	503.6	418.4	1135.1	2892.0	3126.3	2370.7	1381.5	457.2	1136.3	919.7	1822.3	1278.6
1984	387.7	495.0	1673.8	3165.6	3143.0	2067.4	748.6	235.7	733.6	522.7	1073.2	574.1
1985	367.0	545.9	1332.1	3128.9	2882.3	2127.4	699.8	138.3	462.7	542.3	525.4	462.7
1986	737.5	359.1	924.5	3094.1	3159.2	3165.6	1133.7	212.1	497.5	645.3	1044.2	522.4
1987	833.7	1147.4	1364.0	3056.3	2919.9	1734.6	38.4	412.4	780.5	987.4	2084.2	1330.8
1988	894.3	769.7	2280.1	3165.6	3165.6	3120.9	2766.3	2932.8	2022.3	2283.0	1943.3	1450.5
1989	1128.0	1108.1	1738.7	2467.5	1174.9	510.5	751.4	67.7	623.6	1446.8	1933.1	2051.6
1990	794.2	1162.1	2696.2	3165.6	3165.6	1055.4	169.6	611.5	1139.9	1205.2	1856.8	1178.8
1991	1275.9	1290.9	2208.7	3165.6	2734.4	1519.7	377.3	258.1	720.5	695.5	879.2	787.3
1992	3084.5	3119.3	3165.6	3165.6	3165.6	3165.6	3157.5	3156.6	3165.6	3165.6	3165.6	3165.6
1993	1162.5	1184.0	2029.7	3165.6	3165.6	2360.6	723.9	718.7	1065.4	922.0	1128.0	1319.6
1994	1002.6	1468.3	1746.8	3076.0	2690.1	1348.2	849.9	1562.6	967.1	974.6	1278.5	1692.4
1995	1170.4	1064.0	2195.5	3163.9	3059.7	2481.1	1855.1	137.5	980.0	1504.7	1075.4	947.9
1996	862.1	1062.2	1189.4	3165.6	3165.6	2348.2	777.1	614.6	1131.6	1234.4	1177.1	1091.3
1997	1023.0	1182.4	1251.1	3165.6	3165.6	2585.9	1293.6	1097.8	2276.3	2491.2	1315.7	1586.3
1998	922.5	941.7	1467.2	3120.7	3063.9	2437.8	1446.2	1294.8	1784.4	913.1	1093.8	1447.8
1999	961.2	1292.2	1347.1	3148.5	3153.0	3000.8	1365.0	550.4	1635.1	1207.3	1284.0	1157.7
2000	1101.1	1148.2	1680.4	3165.6	3165.6	1995.5	129.7	15.5	438.5	1226.7	954.2	1263.3
2001	1074.4	905.7	2926.2	2934.7	3074.2	1233.5	176.6	0.0	391.1	541.7	544.8	596.1
Mean	725.8	808.1	1481.2	2903.8	2849.5	2021.8	1164.3	682.8	1048.3	1066.9	1040.7	893.8

8

Civil Design

Table of Content

Hydraulic Calculations

Table: Weir Calculation - Basic Data

Maximum discharge, [m^3/s]	Q	99.1
One bay length of crest weir, [m]	b	5.50
Bay number	n	3
Length of crest weir, [m]	B	16.50
Head of crest weir (H), [m]	H	2.01
Level of top of dam [m]	Δ_b	1213.7
Pier width, [m]	a_p	0.5
Maximum discharge of one bay, m^3/s	q	33.0
Weir height, [m]	C_B	2.50
Horizontal path on crest, [m]	δ	1.50
Vertical edges rounding radius, [m]	r	0.25
Acceleration of gravity, [m/s^2]	g	9.81
Shape coefficient	$\sigma_{\hat{o}}$	0.97
Coefficient of full head	$\sigma_{\acute{i}}$	1.00
Bay width with two half pier	B'_B	6.00
Narrow plan (bay) coefficient	$K_{b/BB}$	0.15
Vertical edges rounding coeff.	Kg/b	0.13
Apron width	b_a	17.5
Non-erosion velocity	Vn	1.14

Tabulation formulas

$$Q=\sigma_{\tilde{i}}*\varepsilon*m*B*(2*g)^{0.5}*Ho^{1.5}$$
$$\varepsilon=1-(K_{b/B'B}*K_{\tilde{a}/B})$$
$$\hat{E}_{b/B'B=}1-1.4*(b/B'_B-0.2)^{1.5}$$
$$B'_B=b*n$$
$$K_{g/b}=0.17-(r/(30*b))^{0.5}$$
$$K_{L/H}=H/(H+c_B)$$
$$K_{g/H}=0.17-(r/(30*H))^{0.5}$$
$$\acute{I}_0=H+(V_0^{\wedge 2}/2g)$$
$$V_0=Q/\Omega$$
$$\Omega=B*(c_B+H)$$
$$m=\sigma_{\hat{o}}*\sigma_{\acute{i}}*m_r$$
$$m_r=0.36+(0.1*(2.5-\delta/Hp)/(1+2(\delta/Hp))$$
$$m_r=0.50-0.012(Ho/C_B)$$
$$\sigma_{\tilde{i}=}(1-(1-(1-hn/Ho)/(1-(1-m/0.59)^{0.4}))^2)^{0.5}$$

Table: Calculation of Overflow Dam Hydraulics

Diameter of average particles d50 =0.05m

Head of crest weir	Coeff. of dis-charge	Narrow coeffi-cient	Under-flooding height	Under-flooding coeff.	River depth	Discharge	Velocity in end of apron	Apron slab thickness $t=0.15v_1h_1^{0.5}$	Depth of erosion
Í, [m]	**m**	**ε**	**hn[m]**	**σ_u**	**hr, [m]**	**Q [m^3/s]**	**...**	t, [m]	**..**
0.5	0.483	0.980	-1.58	1.00	0.86	**12.23**	0.81	0.13	2.71
0.6	0.482	0.980	-1.44	1.00	0.99	**16.06**	0.93	0.18	3.37
0.7	0.482	0.980	-1.30	1.00	1.12	**20.21**	1.03	0.22	4.05
0.8	0.481	0.980	-1.17	1.00	1.24	**24.67**	1.13	0.27	4.75
0.9	0.481	0.980	-1.04	1.00	1.37	**29.41**	1.23	0.32	5.46
1.0	0.480	0.980	-0.93	1.00	1.49	**34.41**	1.32	0.38	6.20
1.1	0.480	0.980	-0.82	1.00	1.60	**39.66**	1.41	0.44	6.94
1.2	0.479	0.980	-0.73	1.00	1.71	**45.14**	1.51	0.50	7.70
1.3	0.479	0.980	-0.64	1.00	1.82	**50.84**	1.60	0.56	8.47
1.4	0.478	0.980	-0.56	1.00	1.91	**56.76**	1.69	0.63	9.25
1.5	0.478	0.980	-0.49	1.00	2.01	**62.89**	1.79	0.69	10.04
1.6	0.477	0.980	-0.42	1.00	2.09	**69.21**	1.89	0.76	10.84
1.7	0.477	0.980	-0.35	1.00	2.18	**75.72**	1.99	0.83	11.65
1.8	0.476	0.980	-0.29	1.00	2.25	**82.41**	2.09	0.91	12.46
1.9	0.476	0.980	-0.22	1.00	2.33	**89.28**	2.19	0.98	13.29
2.0	0.475	0.980	-0.16	1.00	2.40	**96.32**	2.30	1.06	16.68
2.1	0.475	0.980	-0.09	1.00	2.47	**103.52**	2.40	1.14	14.96

Table: Calculation of Water Surface Profile

Dam top profile hydraulic calculations	
Head calculation	
Maximum discharge, [m^3/s]	99.1
Length of crest weir, [m]	16.5
Discarge factor of weir	0.475
Acceleration of gravity, [m/s^2]	9.81
Horizontal path on crest, [m]	1.5
Head of crest weir (H_0), [m]	2.10

Weir surface coordinates			
for 1m		for 2.10m	
X, [m]	Y, [m]	X, [m]	Y, [m]
0.00	0.126	0.000	0.265
0.10	0.036	0.210	0.076
0.20	0.007	0.420	0.015
0.30	0.000	0.630	0.000
End horizontal path		2.130	0.000
0.40	0.006	2.340	0.013
0.50	0.027	2.550	0.057
0.60	0.060	2.760	0.126
0.70	0.100	2.970	0.210
0.80	0.146	3.180	0.307
0.90	0.198	3.390	0.416
1.00	0.256	3.600	0.538
1.10	0.321	3.810	0.674
1.20	0.394	4.020	0.827
1.30	0.475	4.230	0.998
1.40	0.564	4.440	1.184
1.50	0.661	4.650	1.388
1.60	0.764	4.860	1.604
1.70	0.873	5.070	1.833
1.80	0.987	5.280	2.073
1.90	1.108	5.490	2.327
2.00	1.235	5.700	2.594
2.10	1.369	5.910	2.875
2.20	1.508	6.120	3.167
2.30	1.653	6.330	3.471
2.40	1.823	6.540	3.828
2.50	1.960	6.750	4.116
2.60	2.122	6.960	4.456
2.70	2.289	7.170	4.807
2.80	2.462	7.380	5.170
2.90	2.640	7.590	5.544
3.00	2.824	7.800	5.930
3.10	3.013	8.010	6.327
3.20	3.207	8.220	6.735
3.30	3.405	8.430	7.151
3.40	3.609	8.640	7.579
3.50	3.818	8.850	8.018
3.60	4.031	9.060	8.465
3.70	4.249	9.270	8.923

Calculation stilling basin, apron	
Apron width, [m]	17.5
Apron wall slope	0
Critical depth function value (h_c)	0.0
Critical depth on apron, [m]	1.53
Depth in river at apron end, [m]	2.42

Weir surface trendline function
$Y=A_6x^6+A_5x^5+A_4x^4+A_3x^3+A_2x^2+A_1x+A_0$

Trendline polynom function coefficients

A_6	A_5	A_4	A_3
0.0028	-0.0729	0.7616	-4.1245
A_2	A_1	A_0	R^2
12.3820	-19.3440	12.1400	1.0000

Derivative function $Y=6A_6x^5+5A_5x^4+4A_4x^3+3A_3x^2+2A_2x+A_1$

Derivative function coefficients

$6A_6$	$5A_5$	$4A_4$	$3A_3$
0.0169	-0.3643	3.0464	-12.3735
$2A_2$	A_1	**Line part angle, [°]**	
24.7640	-19.3440	45	

Weir surface tangent angle, [°]			45.00
at x, [m]	4.65	at Y, [m]	1.385
Conjugating radius, [m]			1.5
Circle arc center Y_0, [m]			1.3
Conjugating tangent angle, [°]			45.00
at false x, [m]	-1.06	at Y, [m]	2.36
at true x, [m]			5.63
Circle arc center X_0, [m]			6.69

Circle arc coordinates		Radius coordinates	
X, [m]	Y, [m]	X, [m]	Y, [m]
5.63	2.361	5.63	2.36
5.71	2.442	6.69	1.30
5.80	2.512	6.69	2.79
5.89	2.572	6.69	1.30
5.98	2.623	**Profile before curve**	
6.07	2.666	First line angle, [°]	
6.16	2.703	-89.0	
6.24	2.733	Height first part, [m]	
6.33	2.758	0.5	
6.42	2.776	Second line angle, [°]	
6.51	2.790	-89.0	
6.60	2.797	Height second part,[m]	
6.69	2.800	2	
First line end point		Second line end point	
X, [m]	Y, [m]	X, [m]	Y, [m]
-0.009	0.765	-0.044	2.765

Profile before curve coordinates

Point	1	2	3
X, [m]	0.000	-0.009	-0.044
Y, [m]	0.265	0.765	2.765

Calculation of depth at end weir surface

Height (weir crest-end dam),[m]	2.8
Factor of velocity	0.97
Bernuly equation value at h	-0.0007
Depth at dam end (h), [m]	0.68
Conjugate depth (h'), [m]	3.12
Depth on apron, [m]	2.37
Stilling basin height, [m]	**0.93**
Losses at apron begin, [m]	0.140
Factor of safety	**1.10**

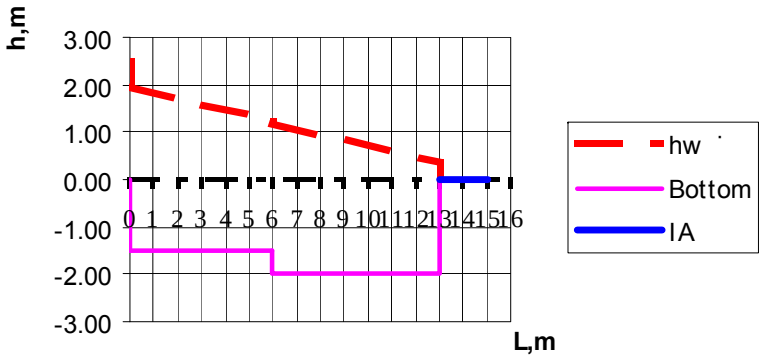
Stilling basin length, [m]	9.78	Apron length, [m]	11.73
Velocity on stilling basin, [m/s^2]	1.75	Velocity on apron, [m/s^2]	2.39

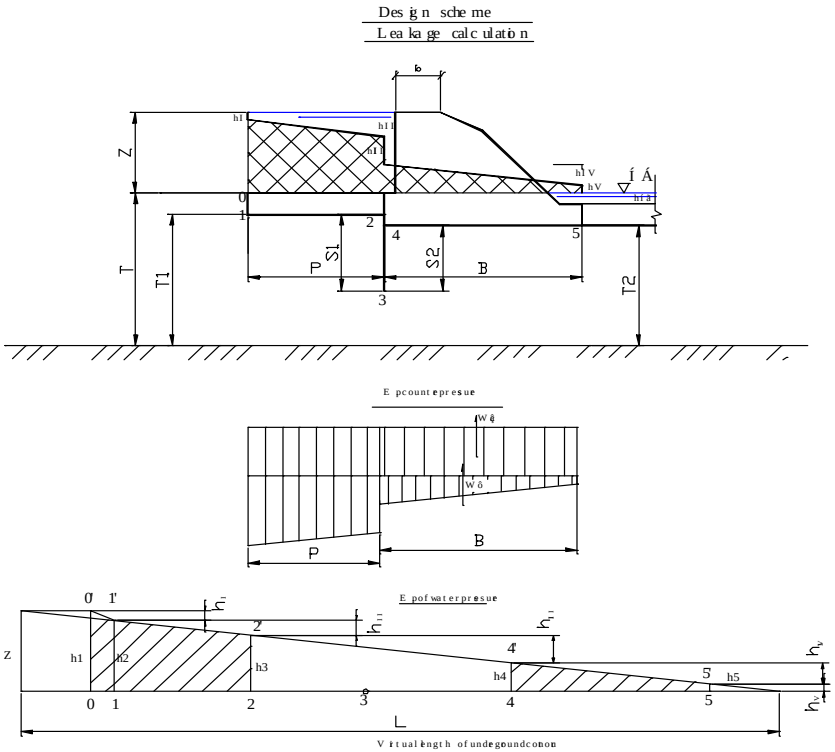
Table: Weir Stability Analysis

Gargar SHPP
Spillway Weir

Calculation of filtration

Hi - head	m	0
H - static head	m	2.5
h_{IA}	m	0.5
Lapron(1-2)	m	6.0
Lie(3-4)	m	7.0
hfoundation.	m	1.5
T(confining layer)	m	7
T1-depth of confining layer from left		6
T2-depth of confining layer from right	m	5.5
h0-1	m	1
h2-3	m	0.5
h4-5	m	0





Piezometric Slope

Virtual length lo=L+2l, m	l=T*0.44	Embedding sheet-pile from the surface S, m	Embedding sheet-pile from apron bottom S1, m	Embedding sheet-pile from weir bottom S2,m	Backpressure ordinates, m					Head Losses, m						Uplift Pressure		
					h_1	h_2	h_3	h_4	h_5	h_I	h_{II}	h_{III}	h_{IV}	h_V	Σhw	Wfiltr	Wweigth	W
20.66	3.08	0	0	0	2.50	2.01	1.28	1.22	0.37	0.49	0.726	0.061	0.847	0.37	2.5	4.27	14	18.2691

2.Method of resistance coefficient

							Resistance Coefficient						Head Losses, m						Uplift pressure		
Virtual length L ,m	Embedding sheet-pile from the surface S m	Embedding sheet-pile from apron bottom S1, m	Embedding sheet-pile from weir bottom S2	Depth of confining layer under bottom from left T1, m	Depth of confining layer under bottom from right T2, m	a=T1-T2	$\xi ao=x_{oi}+0.44$	$\xi 1 horizont.=(L-0.5(S0+S1/T2))/T1$	$\xi sheet pile=a/T1+1.5S/T2+(0.5S/T2)/(1-0.75S/T2)$	$\xi 2 horizont.=(L-0.5(S0+S2/T2))/T2$	$\xi exit=0.44$	$\Sigma\xi$	h_I	h_{II}	h_{III}	h_{IV}	h_V	Σhw	Wfiltr	Wweigth	W
1.Method of prolonged contour line																					
20.7	0	0	0	6	5.5	0.5	0.52	1.00	0.08	1.27	0.44	3.319	0.39	0.75	0.06	0.96	0.33	2.5	5.67	14.00	19.67

Calculation of resistance against flat shear

Basic data

Specific rock cohesion	**t/m³**	**C**	0
Angle of inner friction of foundation rock	**degree**	**ja?**	30
Angle of inner friction as per design surface2/3ϕ>φs<30°	**degree**	**φ_s**	0
Angle of loads inner friction		**ji**	20
Bulk weight of dry rock	**t/m²**	**γ1**	1.9
Rock specific weight	**t/m³**	**γ2**	2.7
Porosity of rocks	**t/m³**	**n**	0.30
Weighted specific weight of load sediments	**t/m³**	**γ4**	1.20
Specific weight of water-saturated load sediments	**t/m³**	**γ5**	2.20
Specific weight of water	**t/m³**	**γw**	1.0
Weir heght(US)	**m**	**H1**	2.5
Weir height (DS)	**m**	**H2**	2.8
Height of II layer of weir	**m**	**H3**	1.8
Crest width	**m**	**bgr**	2.1
Width of II layer of weir	**m**	**b1**	1.4
Width of III layer of weir	**m**	**b2**	2.1
Width of back ridge		a1	0.6
Width of front ridge	**m**	a2	0.5
Foundation width		bf	7.0
Foundation depth (US)	**m**	**hf1**	1.5
Foundation depth (DS)		**hf2**	1.2
Depth of load sediments under bottom	**m**	**hs**	2.0
Water depth above weir-US	**m**	hw1	2.5
Water depth above weir crest	**m**	hw1	0
Water depth above bottom -DS	**m**	hw2	0.5
Slope gradient of design surface to the vertical	**degree**	**e**	0.0
Slope gradient of wall to the surface	**degree**	**e**	0.0
Angle of rock surface	**degree**	**r**	0
Section length	**m**	b	1.0
Overload factor from horizontal pressure of rock		n2	1.2
			0.8
Overload factor from vertical pressure of rock		n1	0.8
Overload factor from structures weight		n	0.95

Horizontal load pressure

Horizontal component of load pressure

$Pi=g_i hi*tg^2(45-f/2)$ Intensivity

$Ei=Pi*hi$

Horizontal component of rock pressure

$Pah_1=Pi+g_i h_{a?1}*tg^{?}(45-f/2)$ (US)

$Eah1=Pa?*ha?1$

$Pah_2=g_i h_{a?2}*tg^2(45-f/2)$ (DS)

$Eah2=Pa?*ha?2$

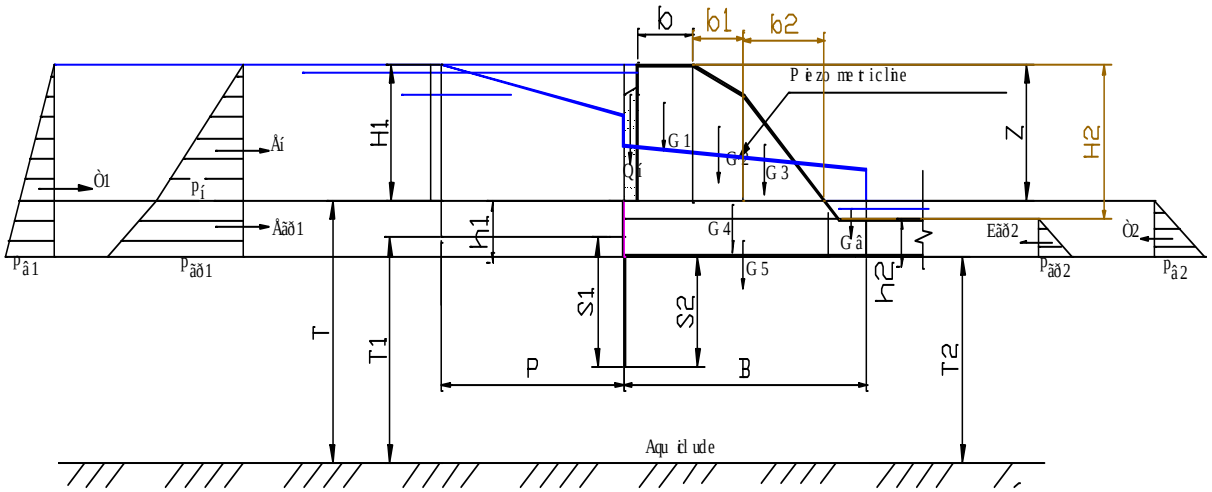
Hydrostatic head

$Pa=g_a ha$ intensivity

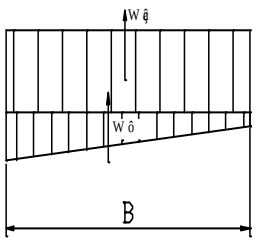
$O1=Pa_1 ha_1$ (US)

$O2=Pa_2 ha_2$ (DS)

Design scheme
Leakage calculation



Epcounterpressure



Calculation of resistance against flat shear

$$\gamma_{1c} * F <= \gamma_c / \gamma_i * R$$

$F = \Sigma Eah$

$R = (\Sigma Eav + \Sigma Q + \Sigma G) * tg f + AgC$

$\gamma 1c$ - coefficient of loads (main)

γc - operation mode coefficient

γ_ι – safety coefficient (IIcl)

Design data

Design rock characteristics			
per design surface of shear:			
upon foundation	f	degree	30
	-tgj		0.58
Rock's specific cohesion	-C	t/m3	0
Bottom width	l	m	7.0
Bottom length	L	m	1
Area of design surface of shear	- A_g	m2	7
Loads coefficient (main)	$\gamma 1c$	-	1.0
Operation mode coefficient	γc	-	1.0
Structures safety coefficient	γ_ι	-	1.20
Bulk weight of the concrete	γ_b	t/m3	2.3

Results of calculation

Embedding sheet-pile from the surface S m	Loads						Balance of restraining forces P, t	Design value of restraining forces R=P*tgj+Ag*c, o	Design value of shear forces F,t	γ_c/γ_n*R	γ_{1c}*F	k = F / R
	Horizontal pressure		Vertical pressure									
	from rock pressure	from hydrost. Pressure	from structures weight	from water weight	from rock weight	from uplift pressure						
	Eh	T	Q.,t	$Ga_{IA}+Ga_{AA}$,t	Ga?, t	W, t						
1.Method of prolonged contour line												
0	3.8	6.0	43.48	0.3	1.0	18.3	26.47	15.28	9.77	12.74	9.77	1.56

Specific load

1. Flood

Design data

Overload factor from horizontal pressure of rock	-	n2	1.2
	-		0.8
Overload factor from vertical pressure of rock	-	n1	0.9
Overload factor from structures weight	-	n	0.95

Loads coefficient (main)	γ1c	-	0.9
Operation mode coefficient	γc	-	1
Structures safety coefficient	γl	-	1.2

Results of calculation

Embedding sheet-pile from the surface S m	Horizontal pressure		Vertical pressure				Balance of restraining forces P, t	Design value of restraining forces R=P*tgj+Ag*c, ò	Design value of shear forces F,t	γ_c/γ_n*R	γ_{1c}*F	k = F / R
	from rock pressure	from hydrost. Pressure	from structures weight	from water weight	from rock weight	from uplift pressure						
	Eh	T	Q.,t	Gus+ Gds ,t	Gr, t	W, t						
0	3.8	14.4	43.48	11.71	1.1	21.9	34.41	19.87	18.17	16.56	16.35	1.1

2. Seismic activity

Embedding sheet-pile from the surface S m	from side pressure of rock		Bulk weight of weir G,t	Seismic accelerative load S,t	from uplift pressure	from rock weight	from hydro-static pressure		Balance of restraining forces R, t	Design value of restraining forces **R=P*tgj+Ag*c**, t	Design value of shear forces **F**,t	R*gc/gn	g1c*F	g1c*F<gc/gn*R
	Balancing of shear forces **Eah1**	Balancing of restraining forces **Eav1**			**W, t**	**G, t**	T_u, t	T_d, t						
0	2.9	0.0	43.48	3.36	19.67	0.86	8.0	2.0	24.67	14.24	12.27	11.9	11.0	**1.16**

Table: Sandtrap - Basic Data

Parameters	Measur. unit	Designation	
Desigh discharge in sediment. basin	m^3/s	Q_s	**1.8**
Maximal muddiness on sedimentation basin inlet	kg/m^3	ρ_{max}	**2.100**
Minimal diameter of the drift in sed.basin	m	d_{min}	**0.00020**
Hidraulic sizes of the drift dmin when tâ=10oC	m/s	W	**0.01711**
Dinsity of the drift	kg/m^3	γ_i	**1.37**
Sediment. basin chamber quantity		n_c	**2**
Average water depth in sedim. basin	m	H_{av}	**2.5**
Coeficient for Sedimentation basin length	-	k	**1.0**
Sed. basin fasing roughness	-	ı	**0.018**
Average depth of the silting volume	m		**0.5**
Chamber slope (accepted for checking)			**0.02**

Table: Determination of the geometrical sizes of the Sandtrap

Parameters	Tabulation formula	Meas. unit	Value
Sedimentation Basin Chamber width	$B_c=H_{av}/1.25$	m	**2.00**
Natural section area of chamber	$\Omega_c=B_c*(H_{av}-h_w)+\Omega_w$	m^2	**4.44**
Discharge in the chamber	$Q_c=Q_{sb}/n_c$	m^3/s	**0.90**
Average velocity of the chamber	$V_{av}=Q_c/\Omega_c$	m/s	**0.20**
Water depth in inlet (for i_{sb}=0.02)	$H_1=H_{av}-i*L/2$	m	**2.16**
Water depth in inlet (for i_{sb}=0.02)	$H_2=H_{av}+i*L/2$	m	**2.84**
Sedimentation basin chamber lenght	$L_s=k*(H_2* V_{av})/W$	m	**33.6**

Table: Calculation of Sedimentation

Fractions	**d**, [mm]	**w**, [m/s]	**h**, [m]	ρ, [kg/m^3]	μ, [l/m^3]	ρ*(**h**/H_2), [kg/m^3]	Quantity of Derivated sediments, [kg/m^3]
Completely formed a sediment	0.5	0.05071	3.14	0.110385	0.08057	0.110385	0.0000
	0.2	0.01711	3.14	0.179821	0.13126	0.179821	0.0000
Partially formed a sediment	0.1	0.00512000	1.13	0.196418	0.14337	0.070531	0.1376
	0.05	0.00171700	0.38	0.225073	0.16429	0.027103	0.2025
	0.01	0.00006800	0.015	0.674777	0.49254	0.003218	0.6721
	0.005	0.00002516	0.0055	0.274829	0.20061	0.000485	0.2744
	0.001	0.00000068	0.00015	0.184190	0.13445	0.000009	0.1842
	<0.001	0.00000010	0.00002	0.254473	0.18575	0.000002	0.2545
TOTAL				**2.09997**		**0.3916**	**1.7253**

Table: Flushing of Sandtrap

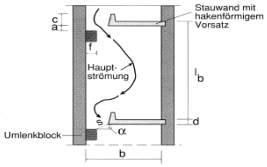
Parameters	Tabulation formula	Meas.unit	Value	Accepted
Washing discharge of the chamber	$Q_w=Qc*(1\div 1.5)$	m3/s	1.35	
Flushing calculated velosity	$V_w=W(h_w/d)^{1/2}p^{1/4}$, p=2...8	m/s	1.21	**1.70**
Average area of natural section for sedimentation basin during flushing	$\omega_w=Q_w/V_w$	m2	0.79	
Depth of the flushing	$h_w=\omega_w B^w_{av}$	m	0.40	
Wet peremeter during sedimentation basin flushing	$\chi = h_w$	m	1.62	
Hydraulic radius during flushing	$R_w=\omega_w/\chi$	m	0.49	
Shezi coefficient	$C_w=R_d\wedge(1/6)/n$		32.28	
Chamber calculated slope			0.00567	**0.020**
Drift volume in the one chamber	$W_{ch}=0.6*h_{av}*b_c*L_c$	m3	60.51	
Weighted concentration	$\mu_p=\mu_{0.5}+\mu_{0.2}$	l/m3	0.21183	
Chamber sedimentation time	T_w/(0.001*Q_c*[μ_p+1/ H_{av}*(Sum(μ_i*h_i))])	hour	66.29	
Sediment transport capacity of flow	$\rho_t=(V_w-0.35)^3/h_w^2$	kg/m3	15.61	
Time of chamber flushing	$T_w=\gamma_H$*VOL_w)/((ρ_t-ρ_0)Q_w)	minute	75.93	

Table: Flushing channel

$h_{ch,}$ [m] (accepted)	n	V_{ch} [m/s]	$\rho_{t,}$ [kg/m^3]	$\omega_{ch}=Q_w/V_{ch}$ [m^2]	$b_{ch=}\omega_{ch}/h_{ch}$ [m]	i	i(accepted)
0.5	**0.0275**	**2**	**17.97**	**0.68**	**1.4**	0.01921	**0.020**

Table: Fishpass

normal U/S water level	[masl]	1214.0
min. U/S water level	[masl]	1213.7
D/S water level	[masl]	1212.4
D/S bed level	[masl]	1212.2
PREDESIGN:		
acc. to Table 5.2:		
slot opening s	[m]	0.15
pool length lb	[m]	2.5
pool width b	[m]	1.2
slot thickness d	[m]	0.2
diff. h (U/S wl - D/S wl)	[m]	1.6
delta h (at each slot)	[m]	0.2
number of pools calc.	[-]	7.0
number of pools	[-]	7
number of pools chosen	[-]	7
number of vertical slots	[-]	8
VERIFICATION:		**min. U/S WL**
U/S transition length l us	[m]	0.75
D/S transition length l us	[m]	0.75
total legth l tot	[m]	19
Substratum d	[m]	0.1
hu	[m]	0.3
min. diff. h (min. U/S - D/S)	[m]	1.3
delta h (at each slot)	[m]	0.16
elevation intake (substrat)	[m]	1213.24
elevation intake (fishladder)	[m]	1213.14
max velocity v max	**[m]**	**1.79**
		o.k.
Discharge Q fish		
hu (D/S)	[m]	0.3
ho (U/S)	[m]	0.46
hu / ho	[-]	0.65
discharge coeff. (Table 5.22)	[-]	0.57
discharge Q fish	[m3/s]	**0.079**
Turbulence conditions:		
mean depth h	[m]	0.38
energy exist.	**[W/m3]**	**120**
		o.k.



Tafel 5.2: Mindestabmessungen von Schlitzpässen für Anlagen mit einem Schlitz (Maße in m) (nach GEBLER, 1991 und LARINIER,1992a)

zu berücksichtigende Fischfauna		Äsche, Blei, Döbel, sonstige Bachforelle	Lachs, Meerforelle, Huchen	Stör
Schlitzbreite	s	0,15 – 0,17	0,30	0,60
Beckenbreite	b	1,20	1,80	3,00
Beckenlänge	l_b	1,90	2,75 – 3,00	5,00
Länge des Vorsatzes	c	0,16	0,18	0,40
Versatzmaß	a	0,06 – 0,10	0,14	0,30
Breite des Umlenkblockes	f	0,16	0,40	0,84
Wasserspiegeldifferenz	h	0,20	0,20	0,20
min. Wassertiefe	h_{min}	0,50	0,75	1,30
erforderlicher Abfluß *)	Q in m³/s	0,14 – 0,16	0,41	1,40

*) ermittelt für Δh = 0,20 m und h_{min}

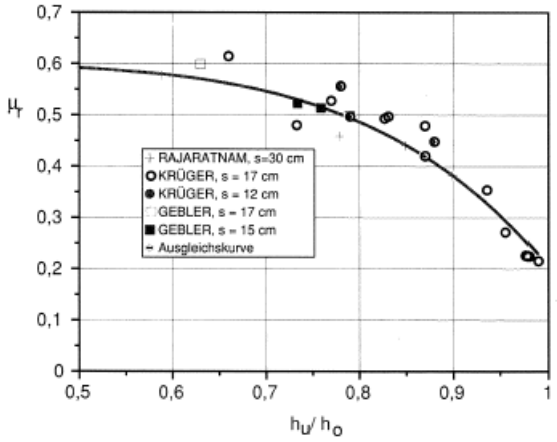


Bild 5.22: Abflußbeiwert $\mu_r = f(h_u/h_o)$ in Gl.(5.9) für scharfkantige Schlitzbegrenzungen

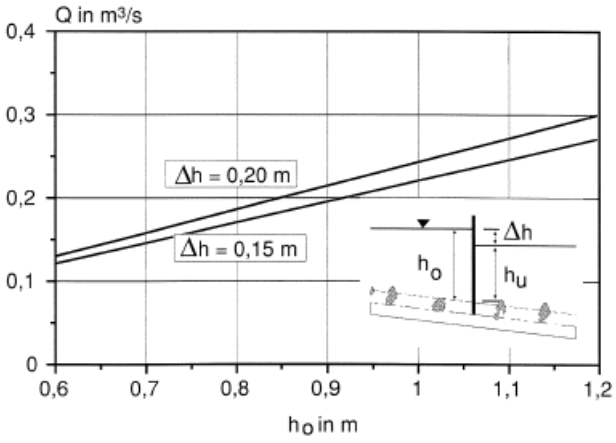


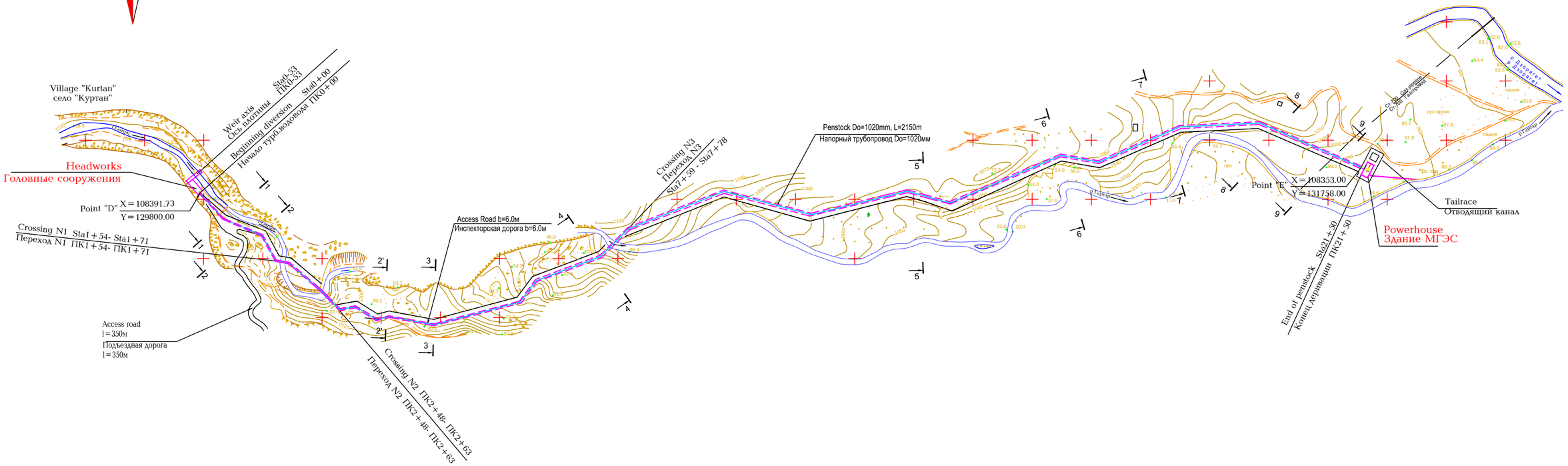
Bild 5.21: Abfluß im Schlitzpaß mit einer Schlitzweite von s = 17 cm

Drawings

N

PLAN
ПЛАН

M1:5000



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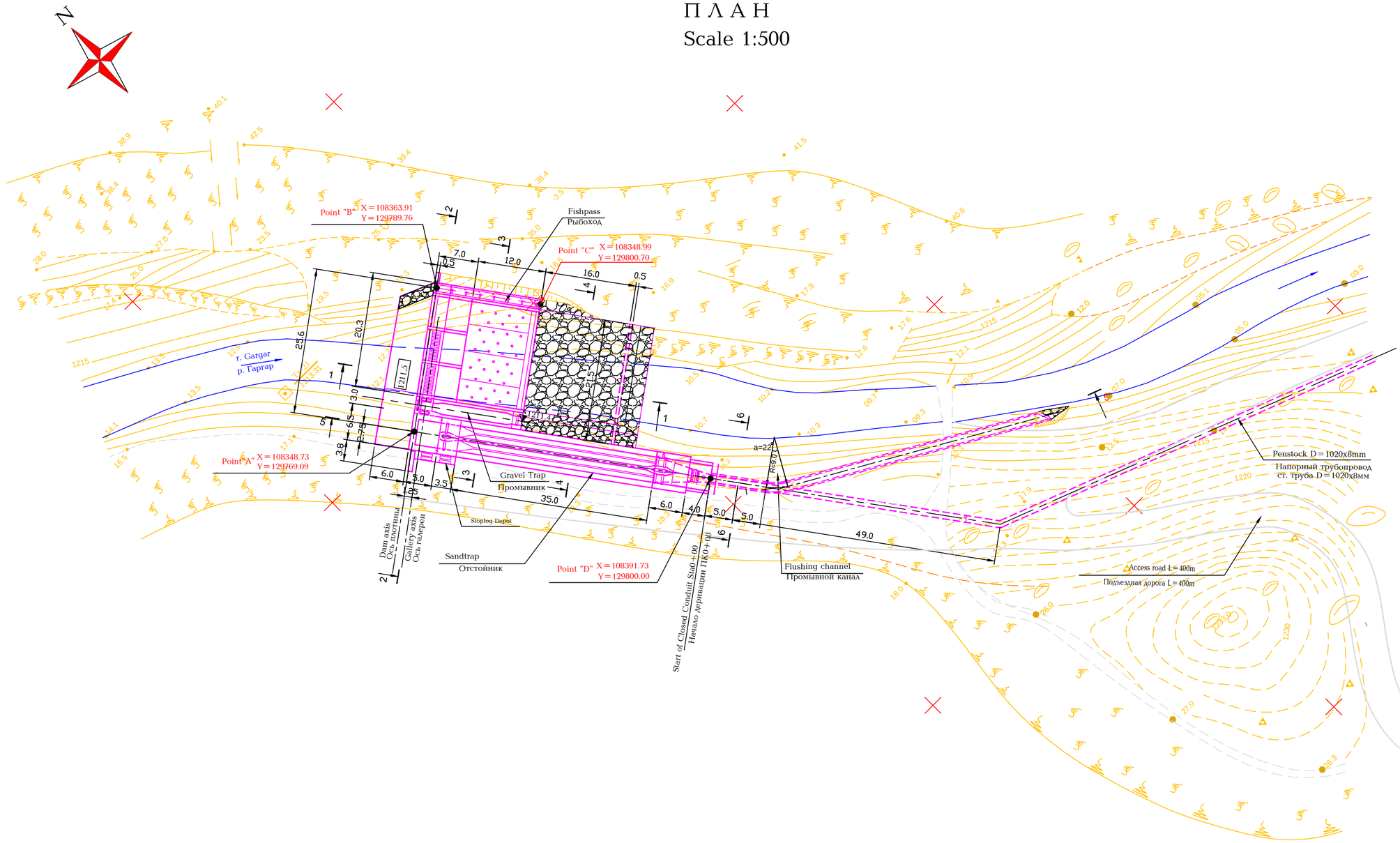
Checked:	September	Palt	Layont-Plan View		Sheet: 1 of 1
Supersedes:					
Superseded by:			Size: 297x594	Project No.: 5761A25	Document No: 12672434
System: AutoCAD 2002			Annex: 8	Drawing No.:	BW20A001

P L A N

П Л А Н

Scale 1:500



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Checked:	September	Palt	Headworks Plan View		Sheet: 1 of 1
Supersedes:					
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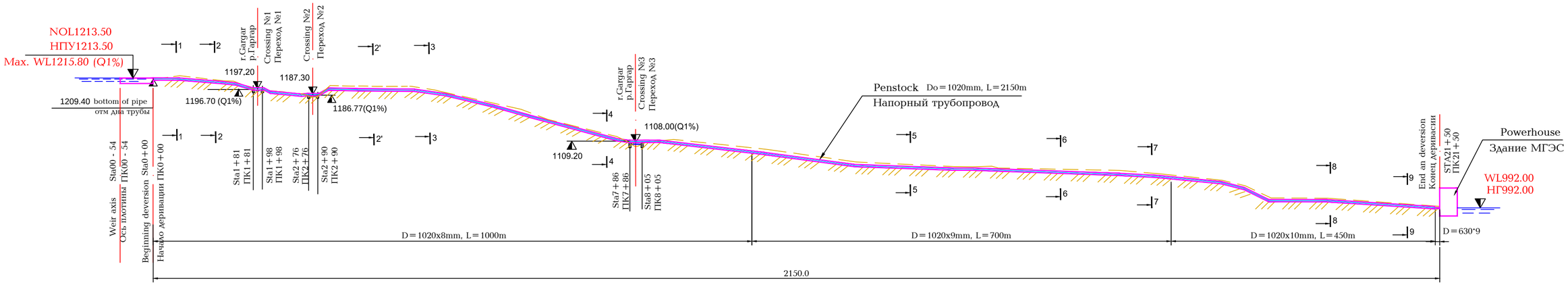

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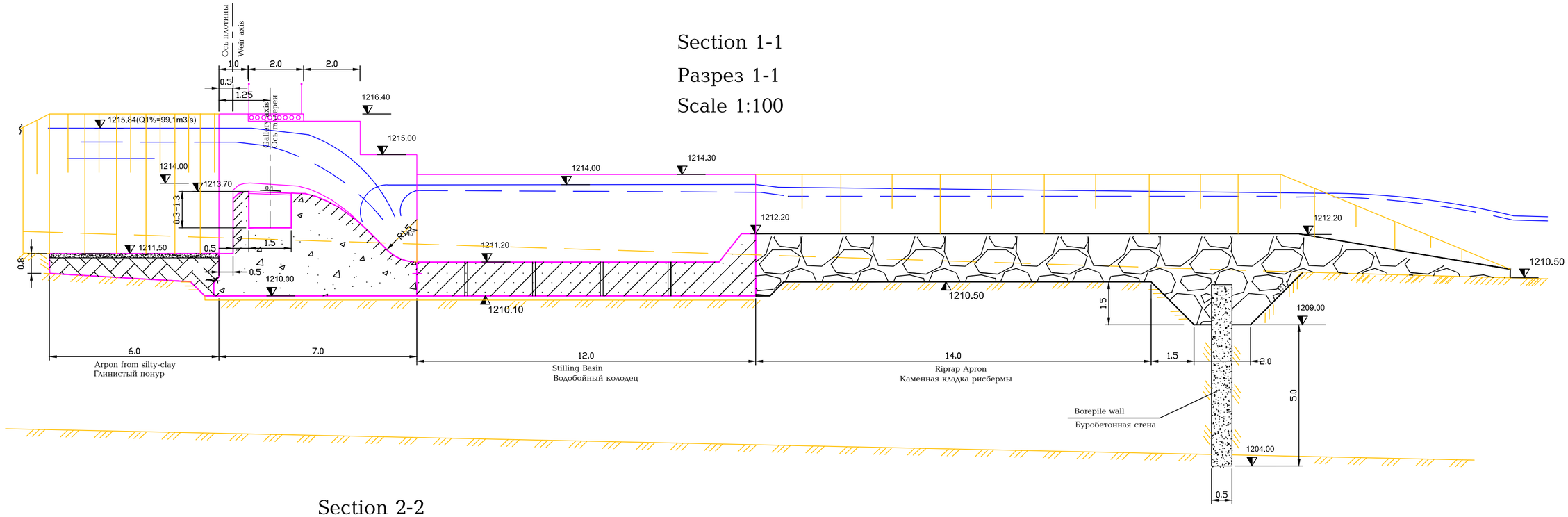
Checked:	September	Palt	Layout-Longitudinal Section		Sheet: 1 of 1
Supersedes:					
Superseded by:			Size: 297x594	Project No.: 5761A25	Document No: 12672434
System: AutoCAD 2002			Annex: 8	Drawing No.:	BW20G001

Section 1-1
Разрез 1-1
Scale 1:100



Section 2-2
Разрез 2-2
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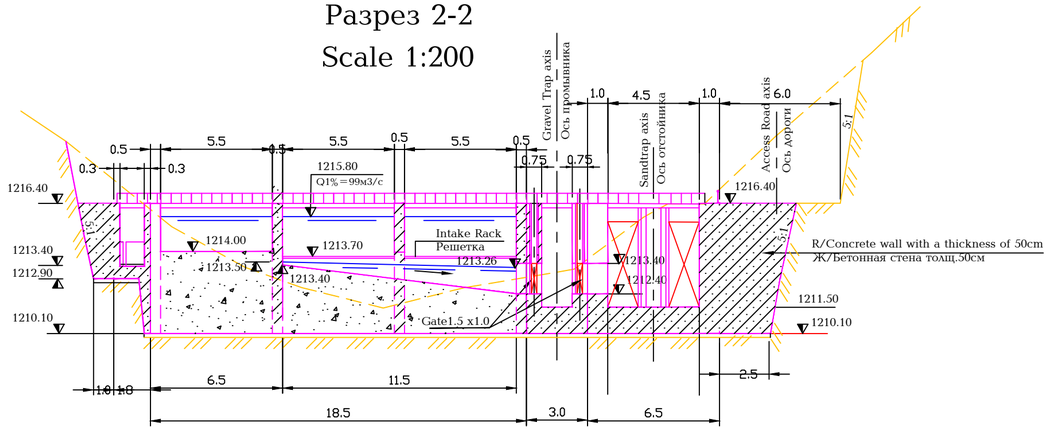

Section 3-3
Разрез 3-3
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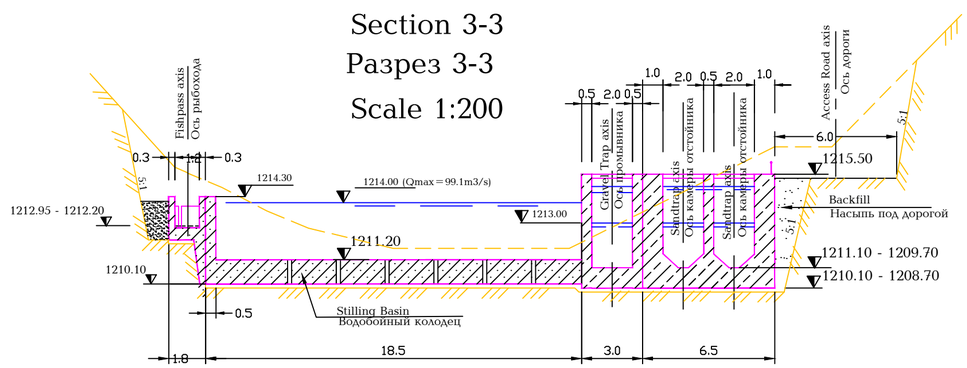

Section 4-4
Разрез 4-4
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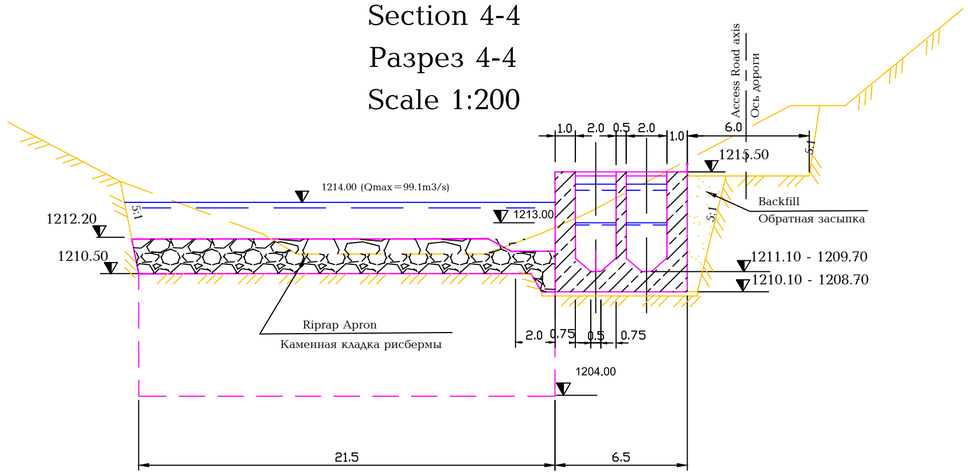

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Checked:	September	Palt	Headworks		Sheet: 1
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Section 5-5
Разрез 5-5
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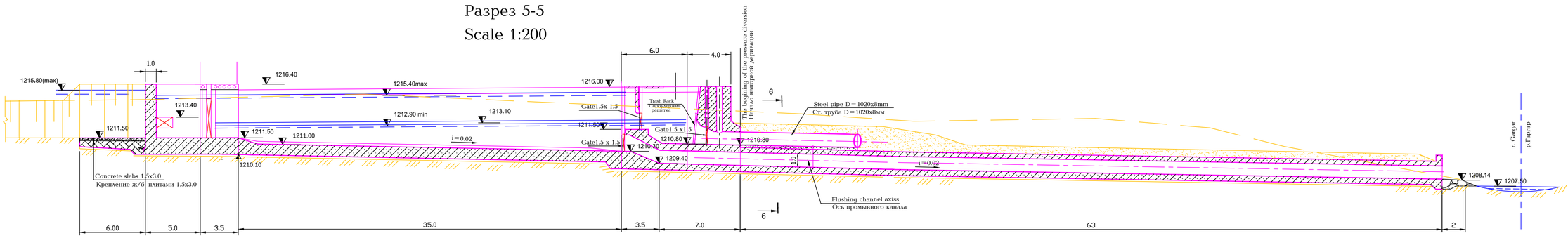

Section 6-6
Разрез 6-6
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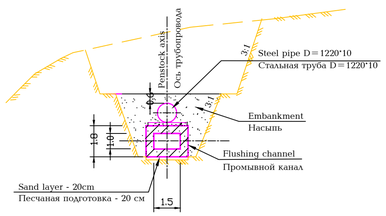

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Checked:	September	Palt			Sheet: 1
Supersedes:					of 1
Superseded by:			Size: 297x841	Project No.: 5761A25	Document No: 12672434
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Section A-A
Разрез A-A
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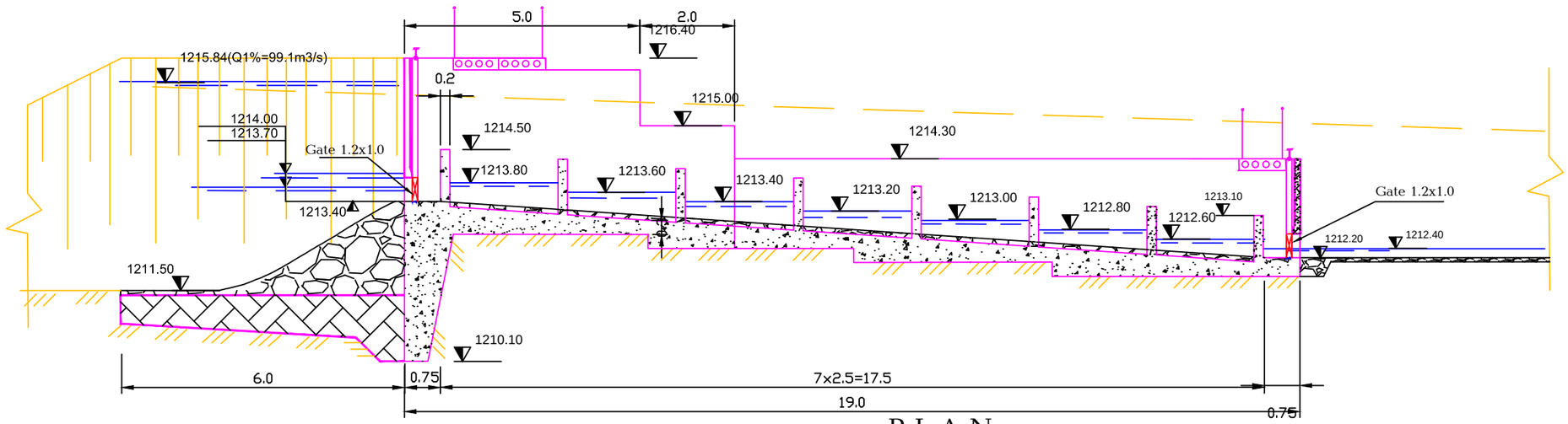

P L A N
П Л А Н
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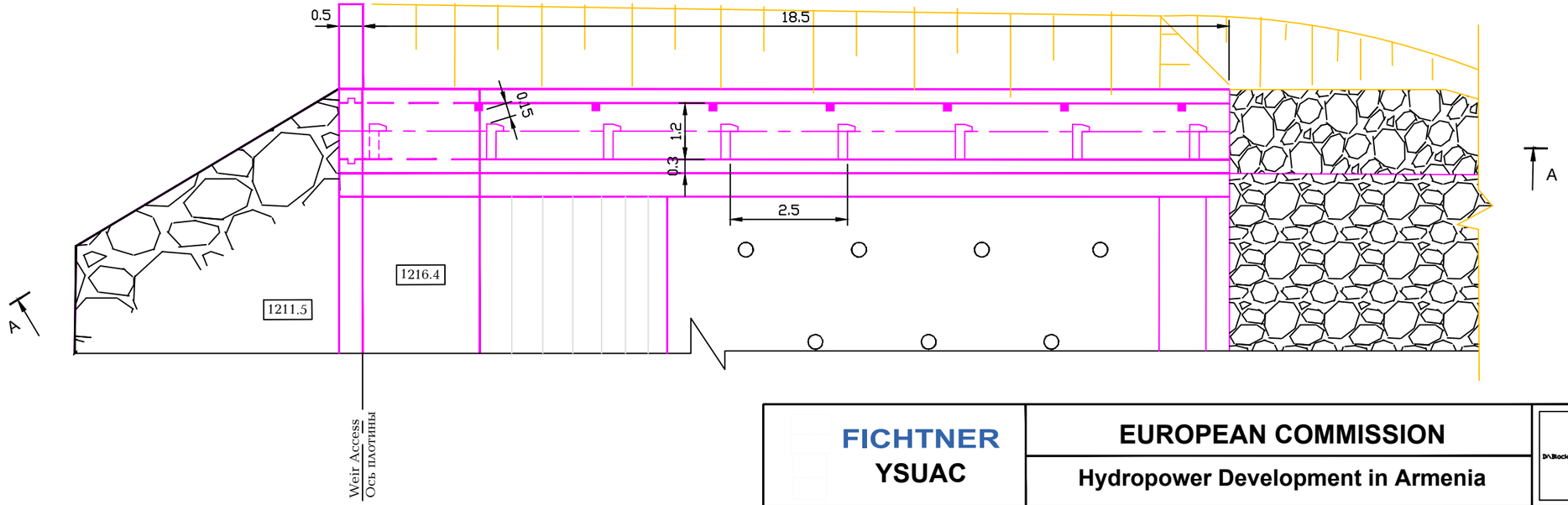

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Checked:	September	Palt	Fishladder		Sheet: 1 of 1
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Crossings №1, №2
Переходы №1, №2

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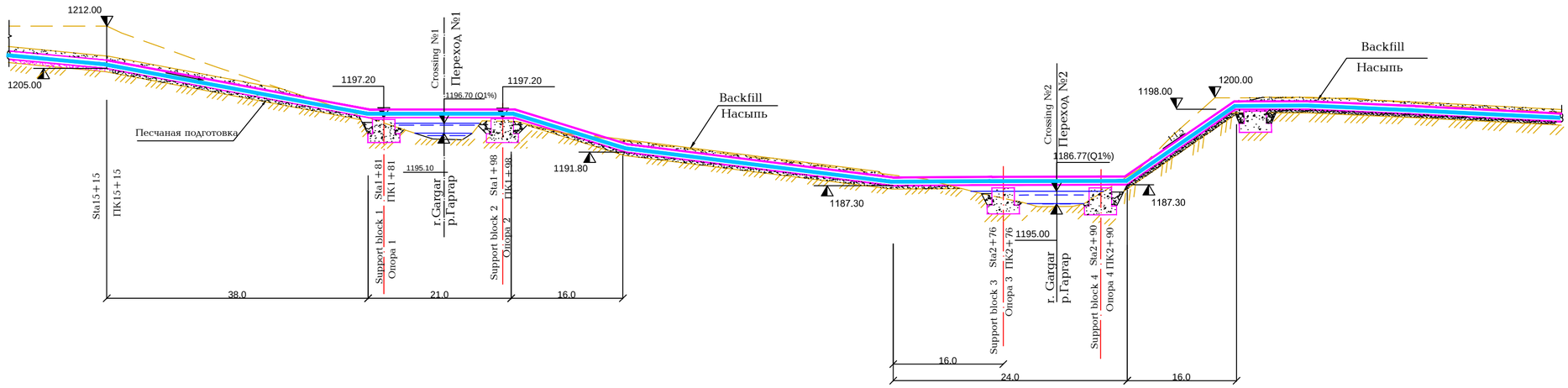

Crossing №3
Переход №3

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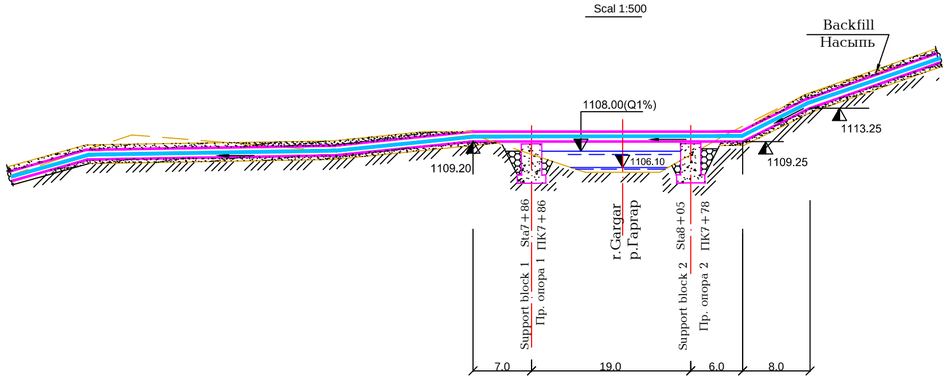
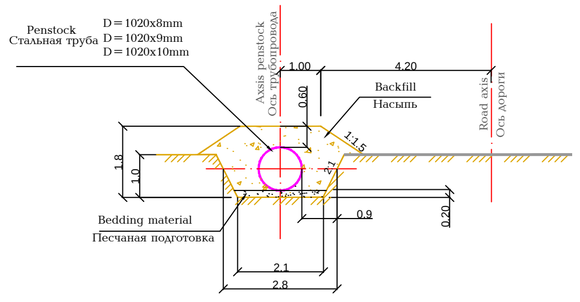


Typical Section
Расчетное сечение

Sc.1:100



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Checked:	September	Palt	Penstock		Sheet: 5
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System: AutoCAD 2002			Annex: 8	Drawing No.:	BW36A005

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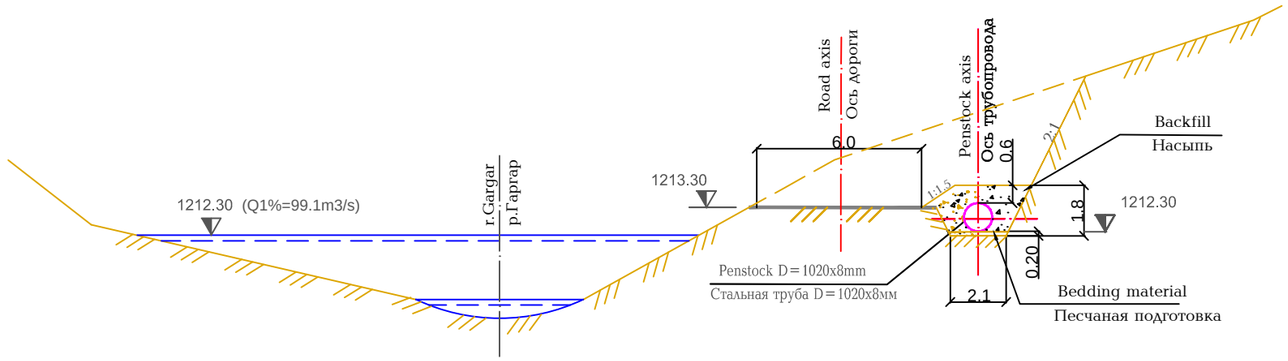

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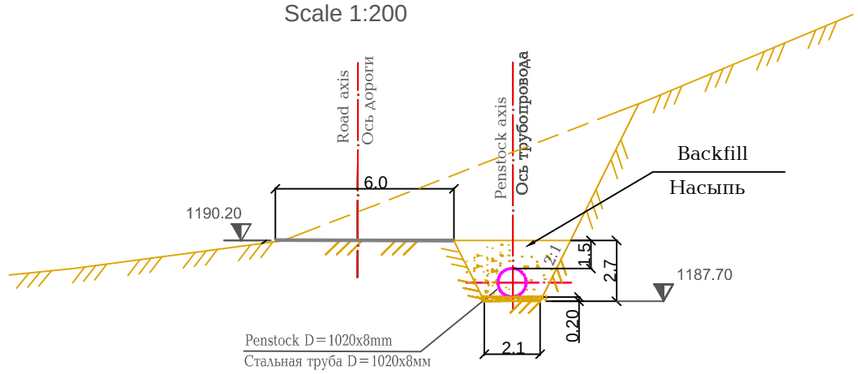

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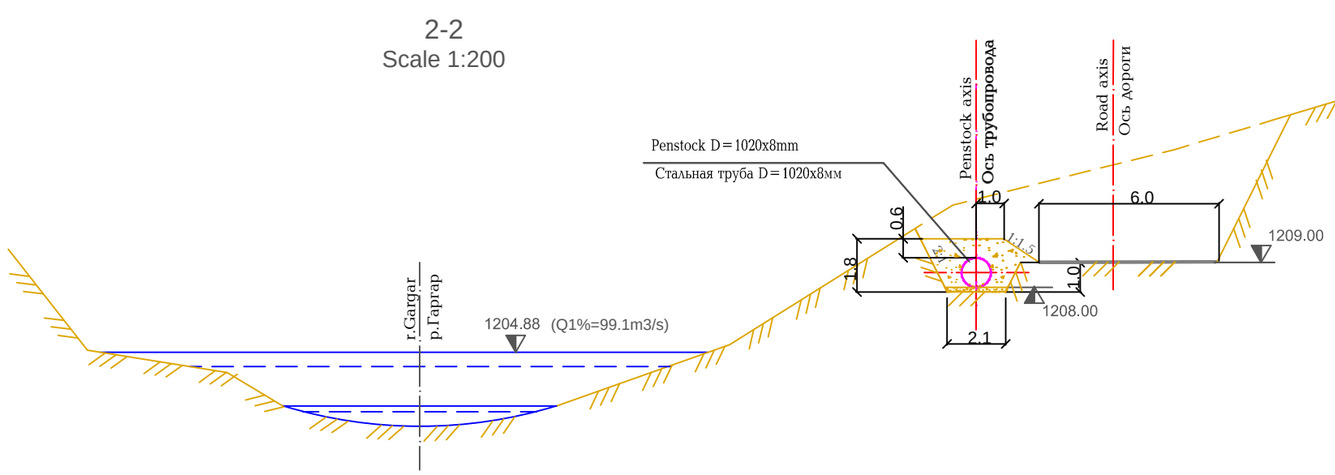

2'-2'
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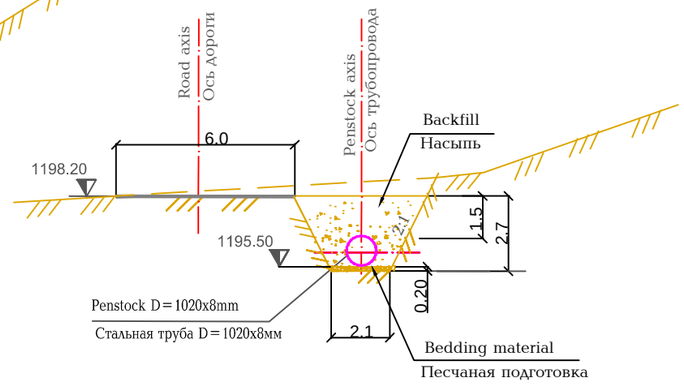

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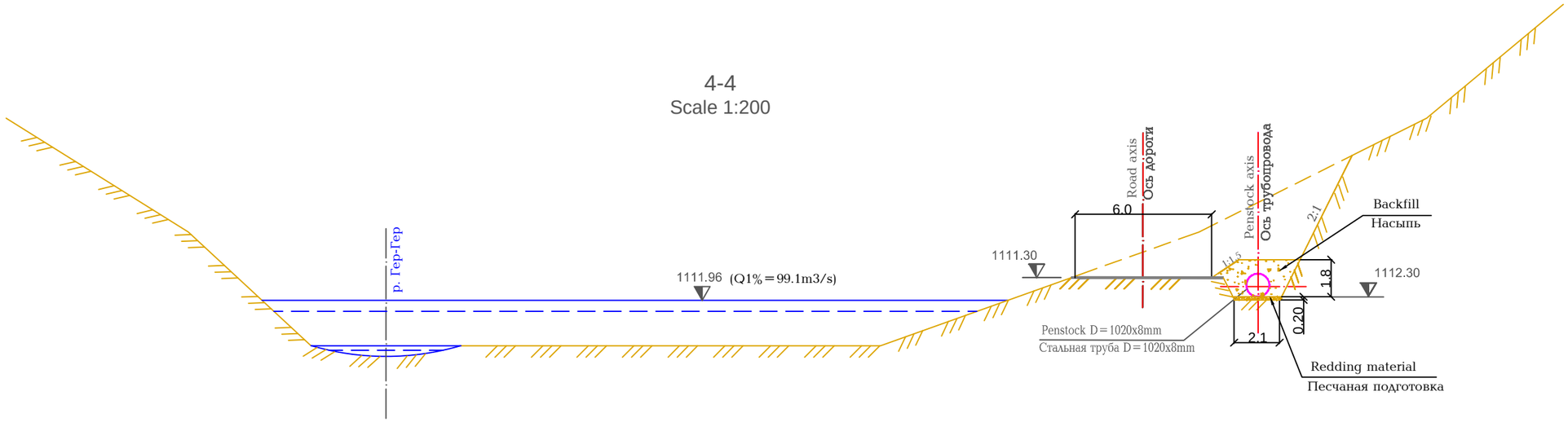
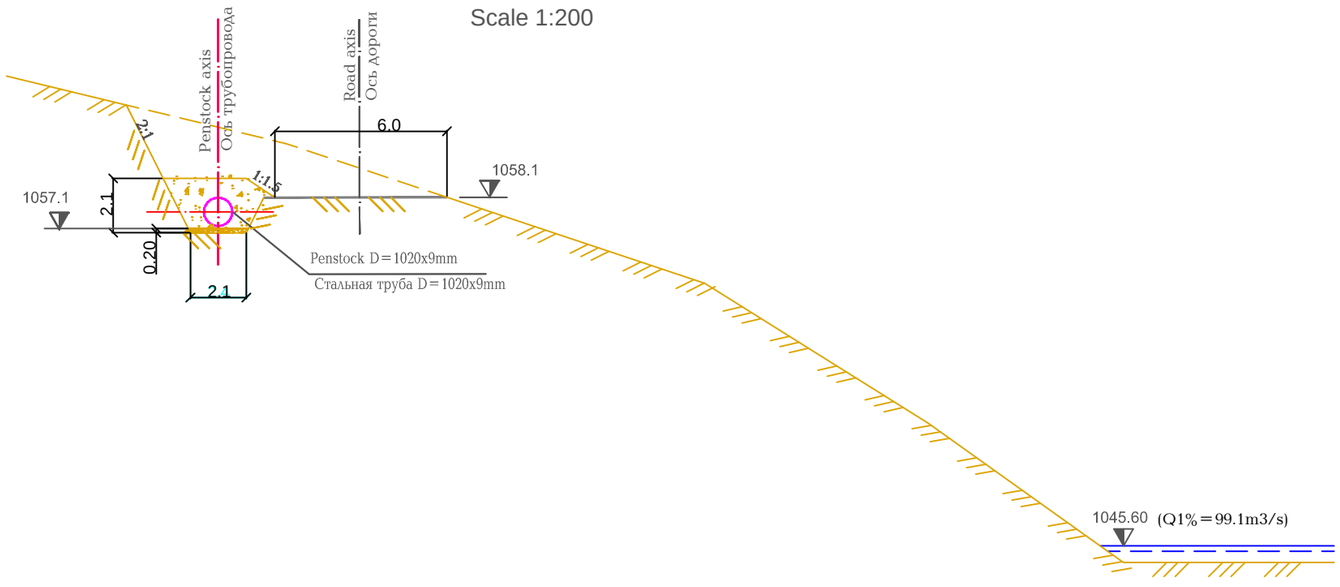
Date / Name Drawn: Palanjyan Checked: Plat Supersedes:	Gargar SHPP **Penstock** Sections 1-3	Scale: 1:200 Sheet: 1 of 5
Superseded by:	Size: 297x420	Project No.: / Document No: 12672374
System: AutoCAD 2002	Annex: 8	Drawing No.: BW36G001

4-4
Scale 1:200



5-5
Scale 1:200



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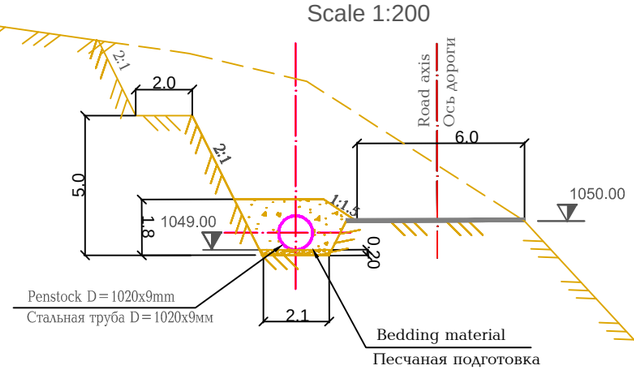
6-6
Scale 1:200



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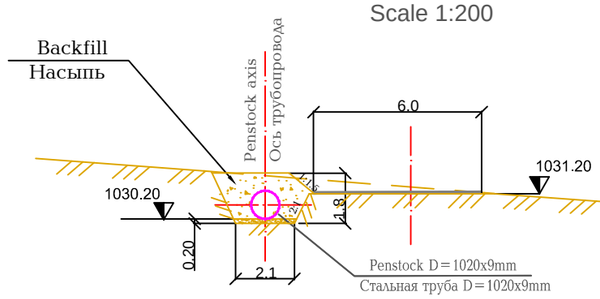

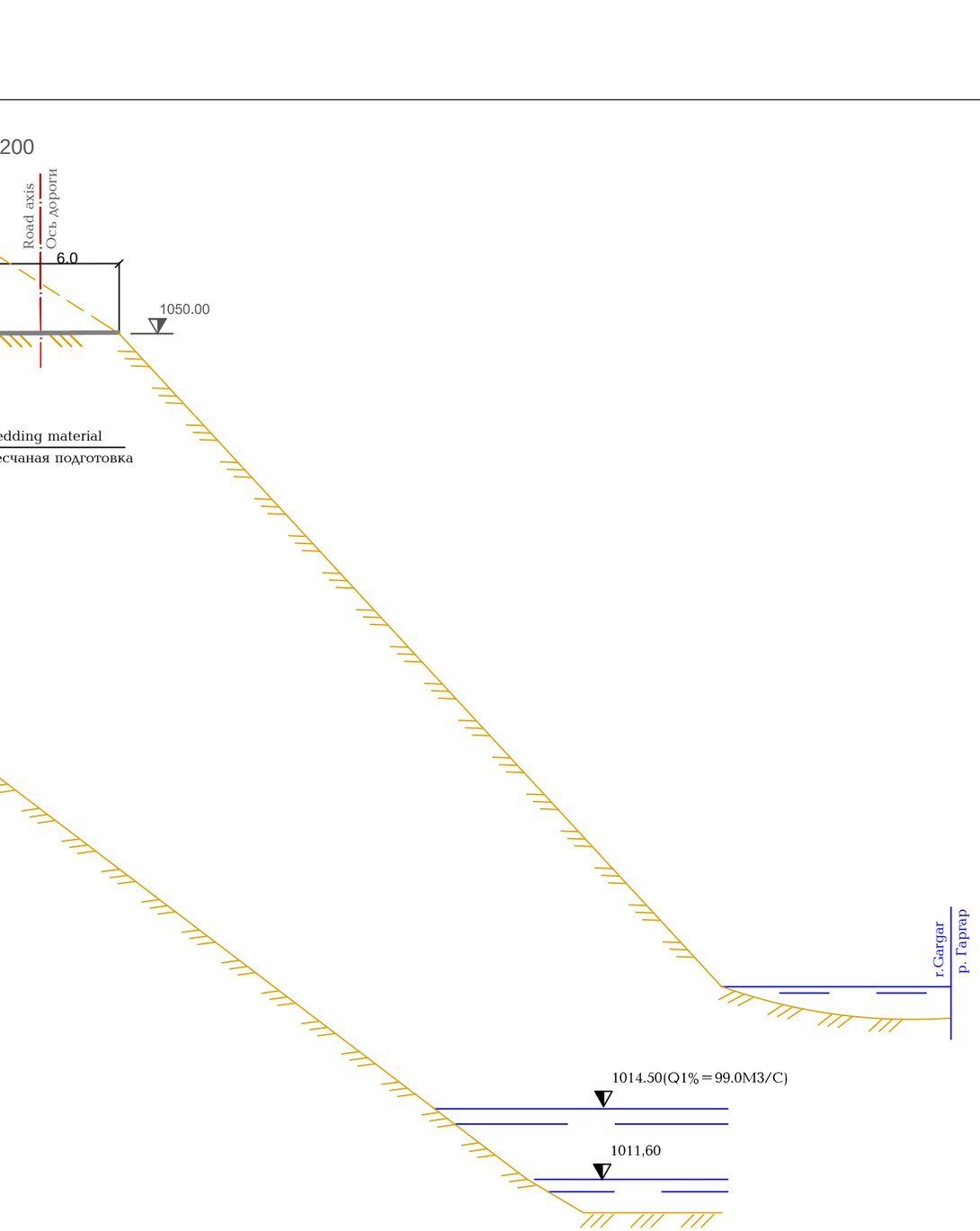

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Supersedes:			Sections 6-7		
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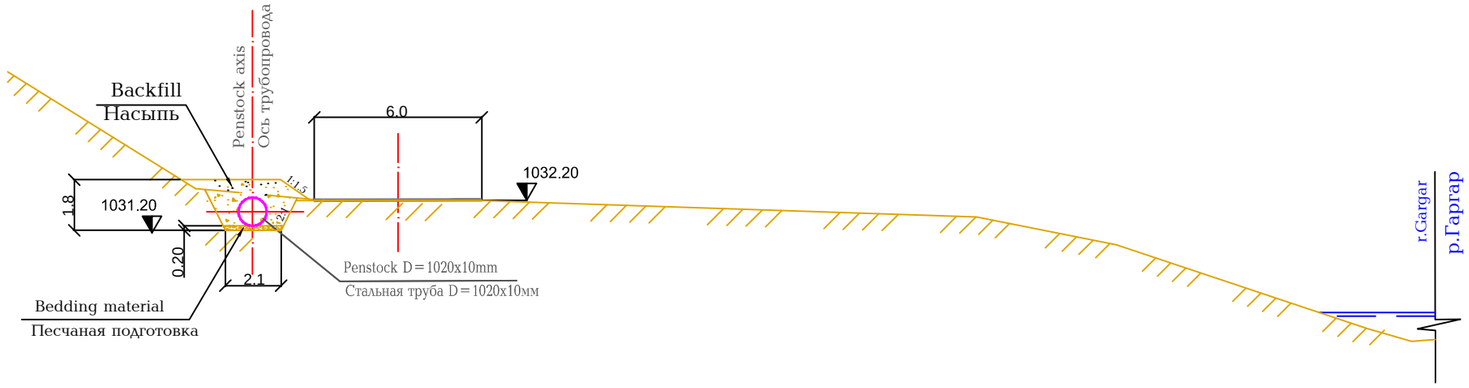
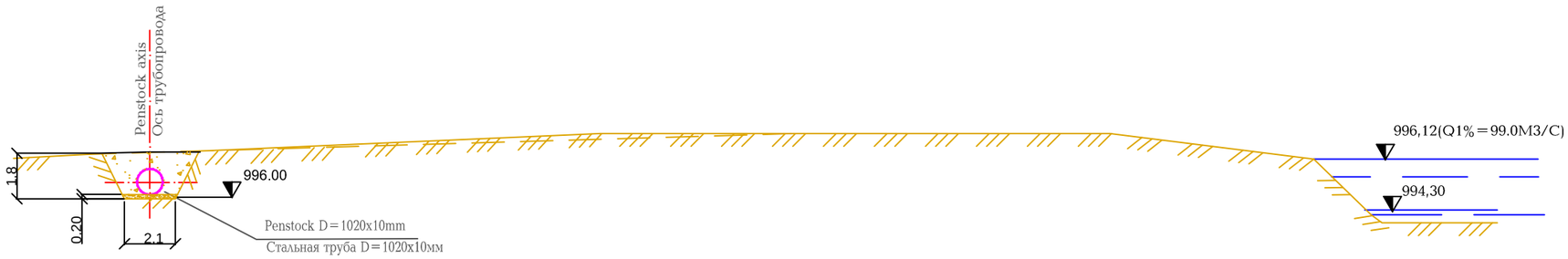
System: AutoCAD 2002			Annex: 8	Drawing No.:	BW36G003

8-8
Scale 1:200



9-9
Scale 1:200



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Checked:		Plat	Penstock		Sheet: 4
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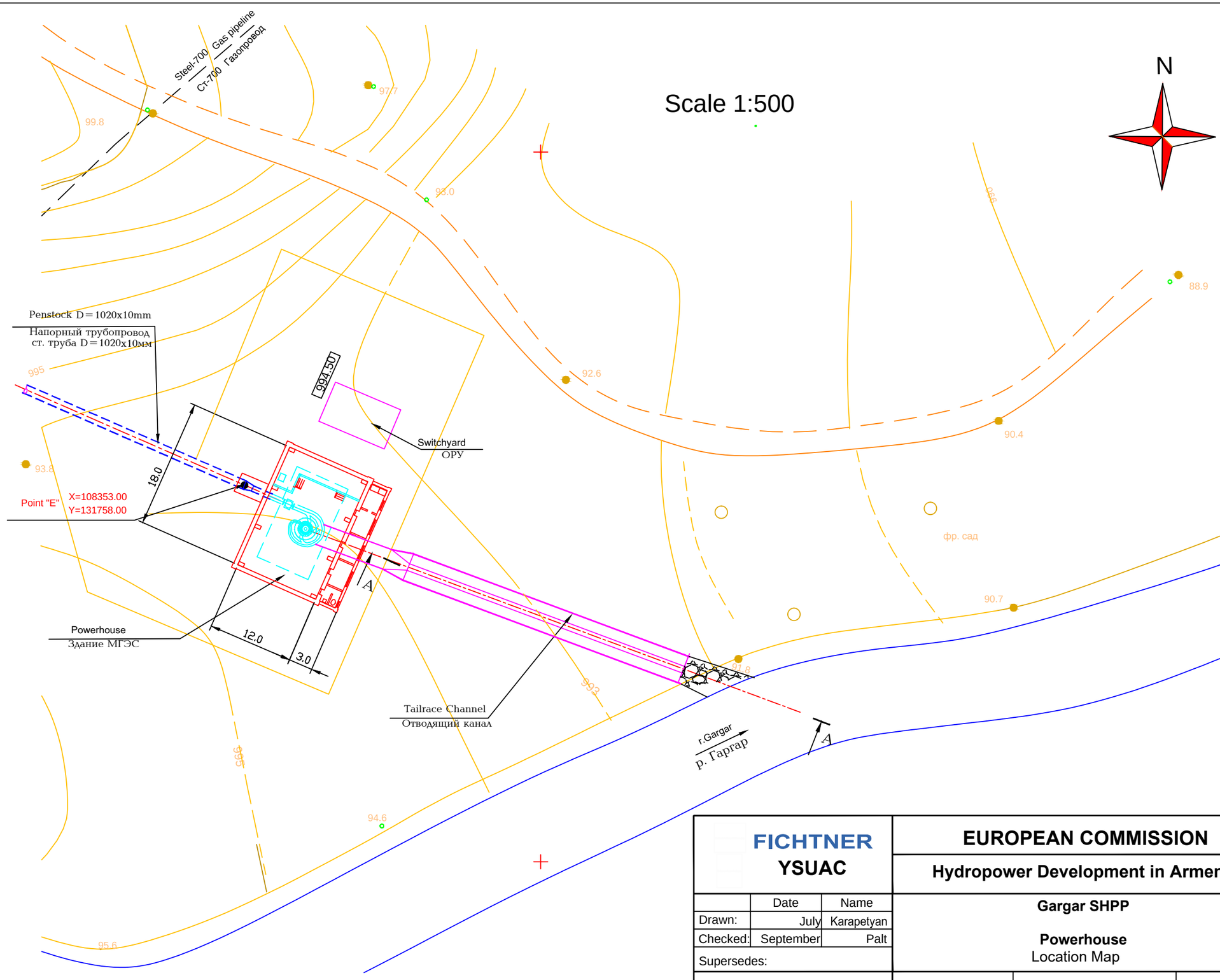
Superseded by:			Size: 297x420	Project No.:	Document No: 12672374
System: AutoCAD 2002			Annex: 8	Drawing No.:	BW36G004



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Checked:	September	Palt	Powerhouse Location Map		Sheet: 1 of 1
Supersedes:					
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System: AutoCAD 2002			Annex: 8	Drawing No.:	BW41A001

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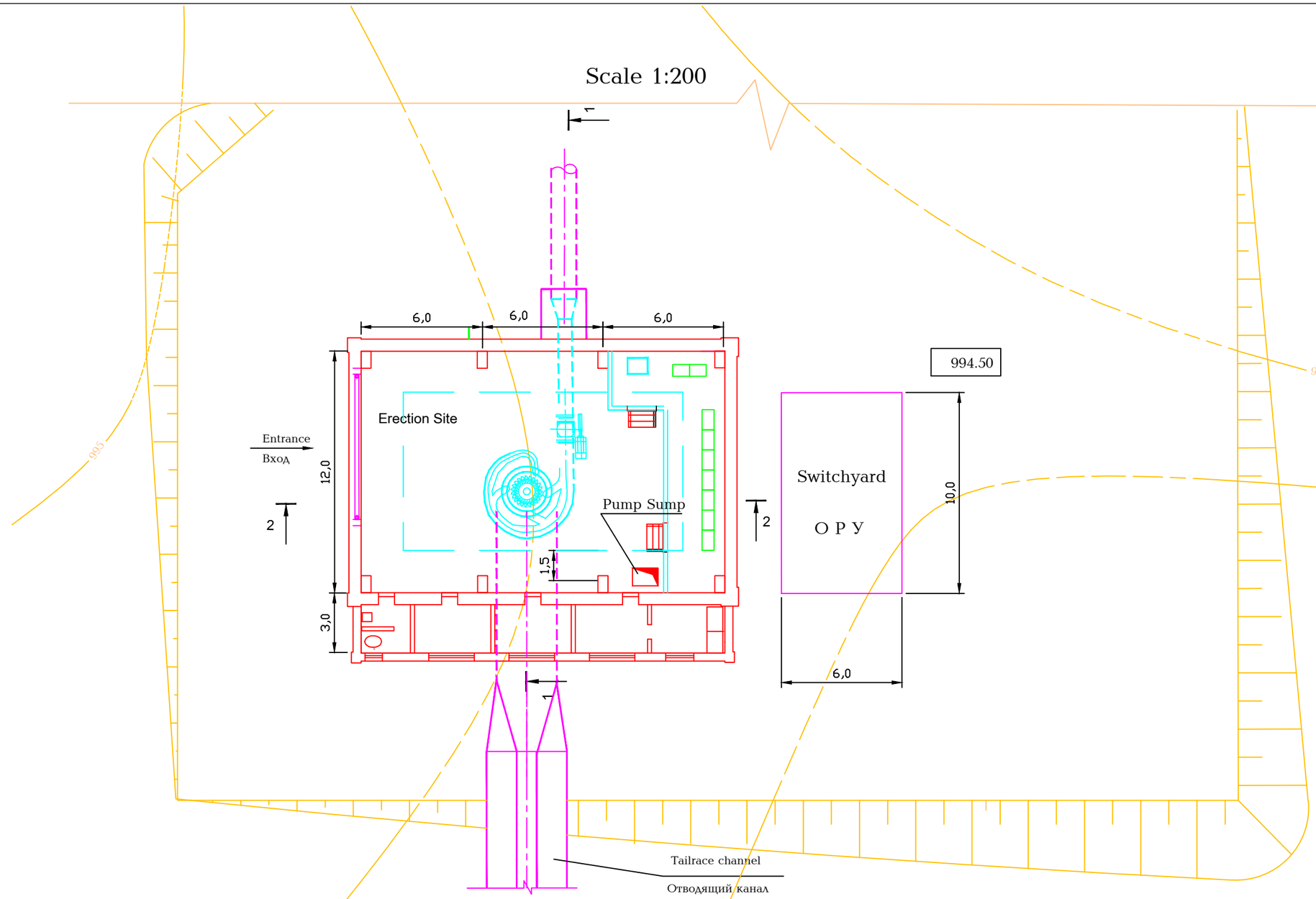

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Checked:	September	Palt	Powerhouse Plan View		Sheet: 1 of 1
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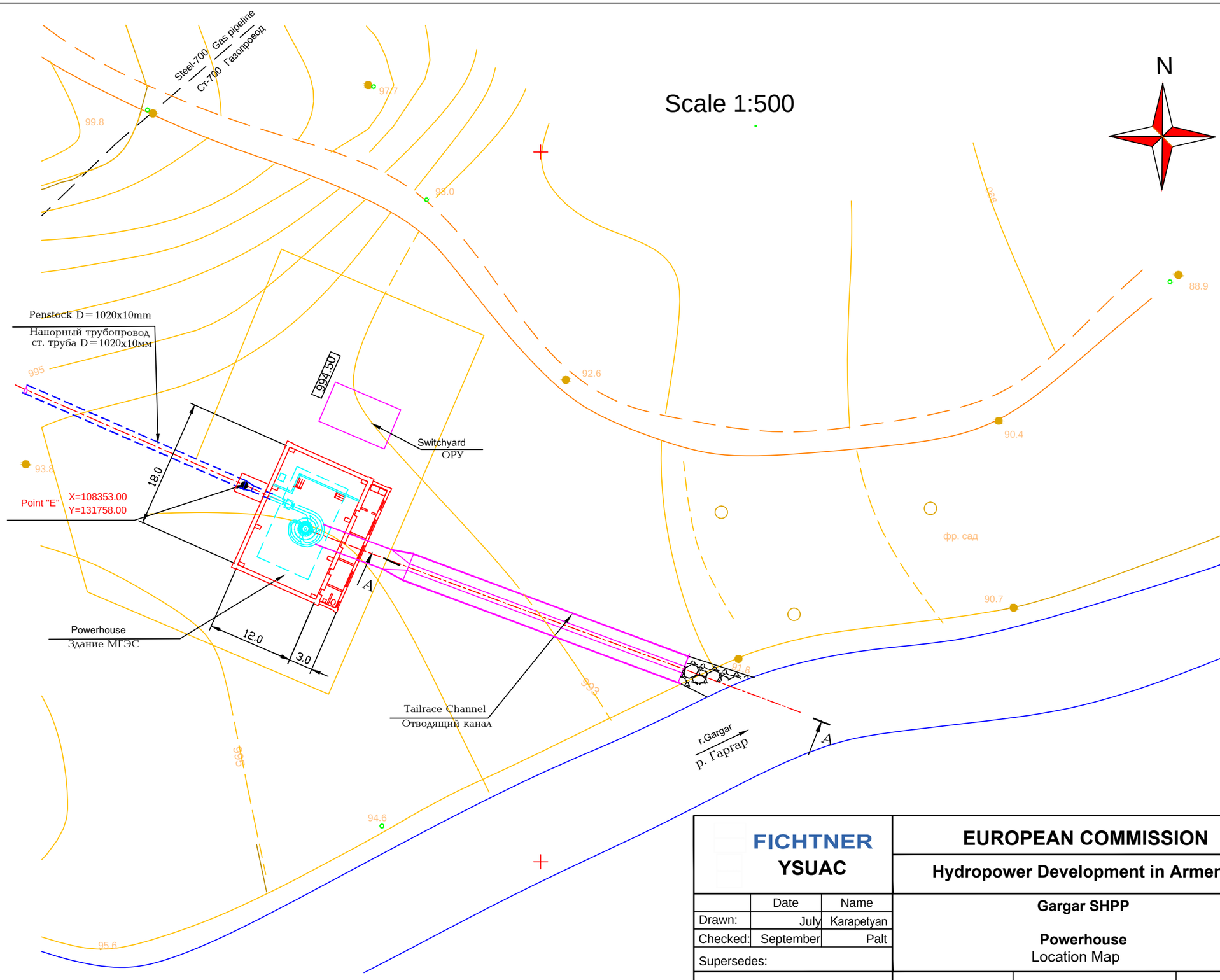
System: AutoCAD 2002			Annex: 8	Drawing No.:	BW41A002



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Supersedes:					
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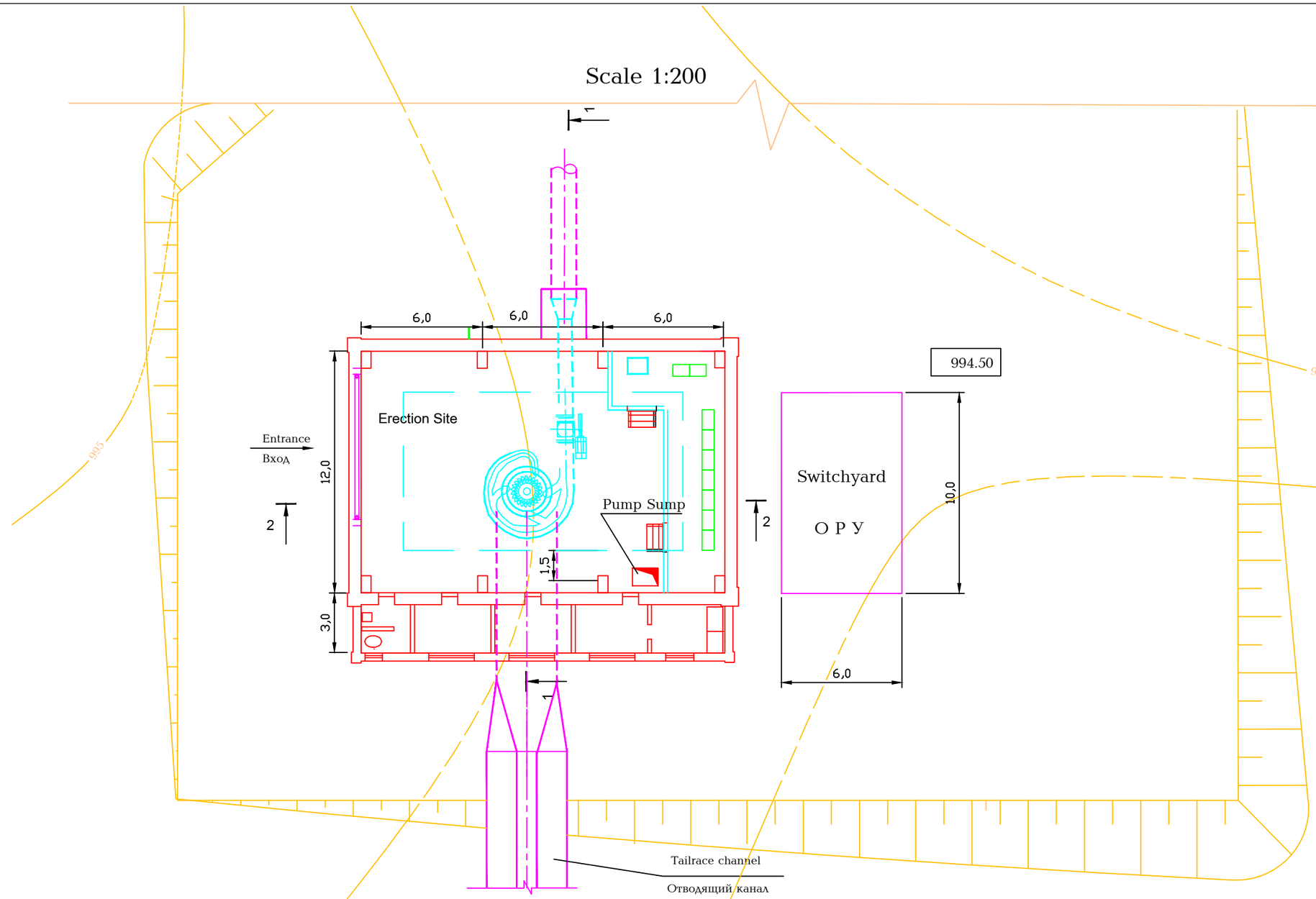

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	Date	Name	Gargar SHPP		Scale: 1:200
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Checked:	September	Palt	Powerhouse Plan View		Sheet: 1 of 1
Supersedes:					
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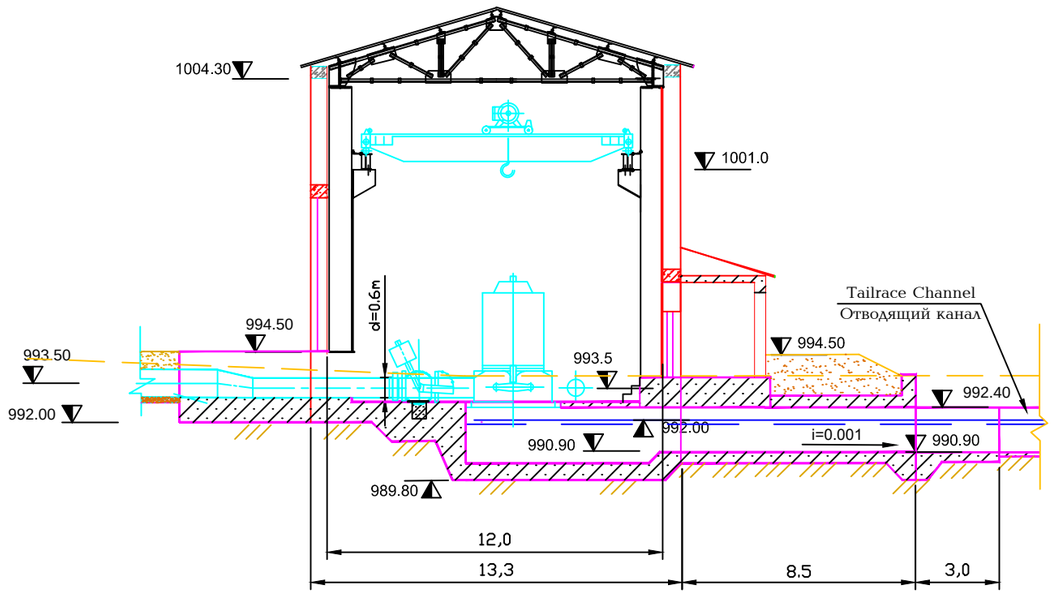

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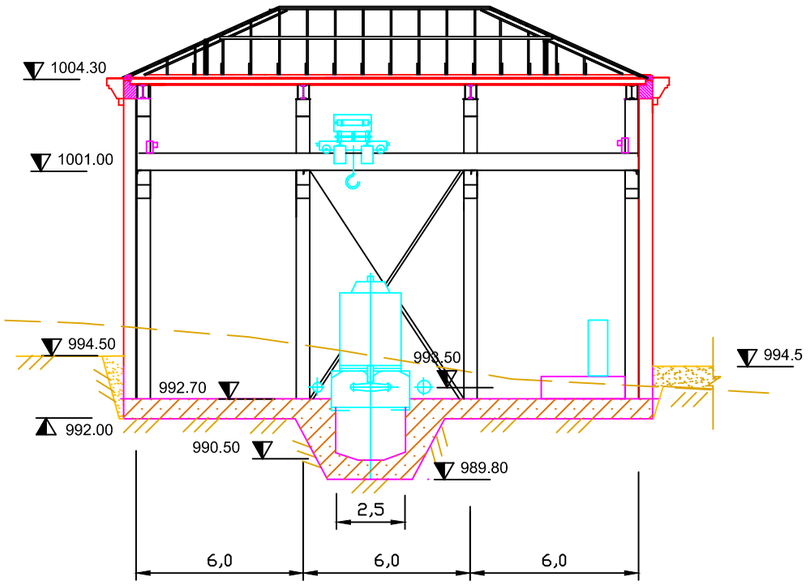

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Checked:	September	Palt	Powerhouse		Sheet: 1 of 1
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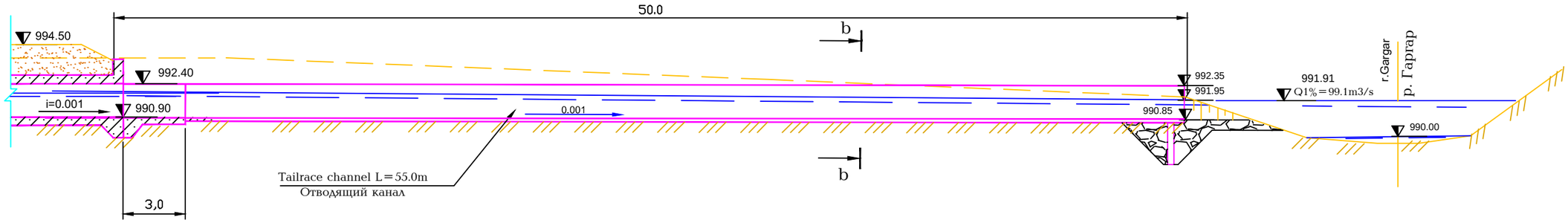

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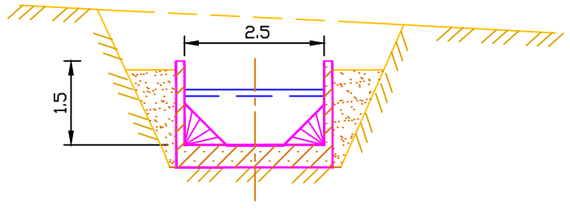

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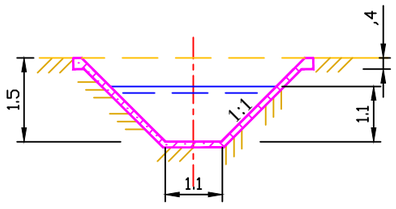

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Checked:	September	Palt	Tailrace Channel Sections A-A, a-a, b-b		Sheet: 1 of 1
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Superseded by:			Size: A3	Project No.: 5761A25	Document No: 12672434
System: AutoCAD 2002			Annex: 8	Drawing No.:	BW41G002

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Electrical Equipment

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Single Line Diagram

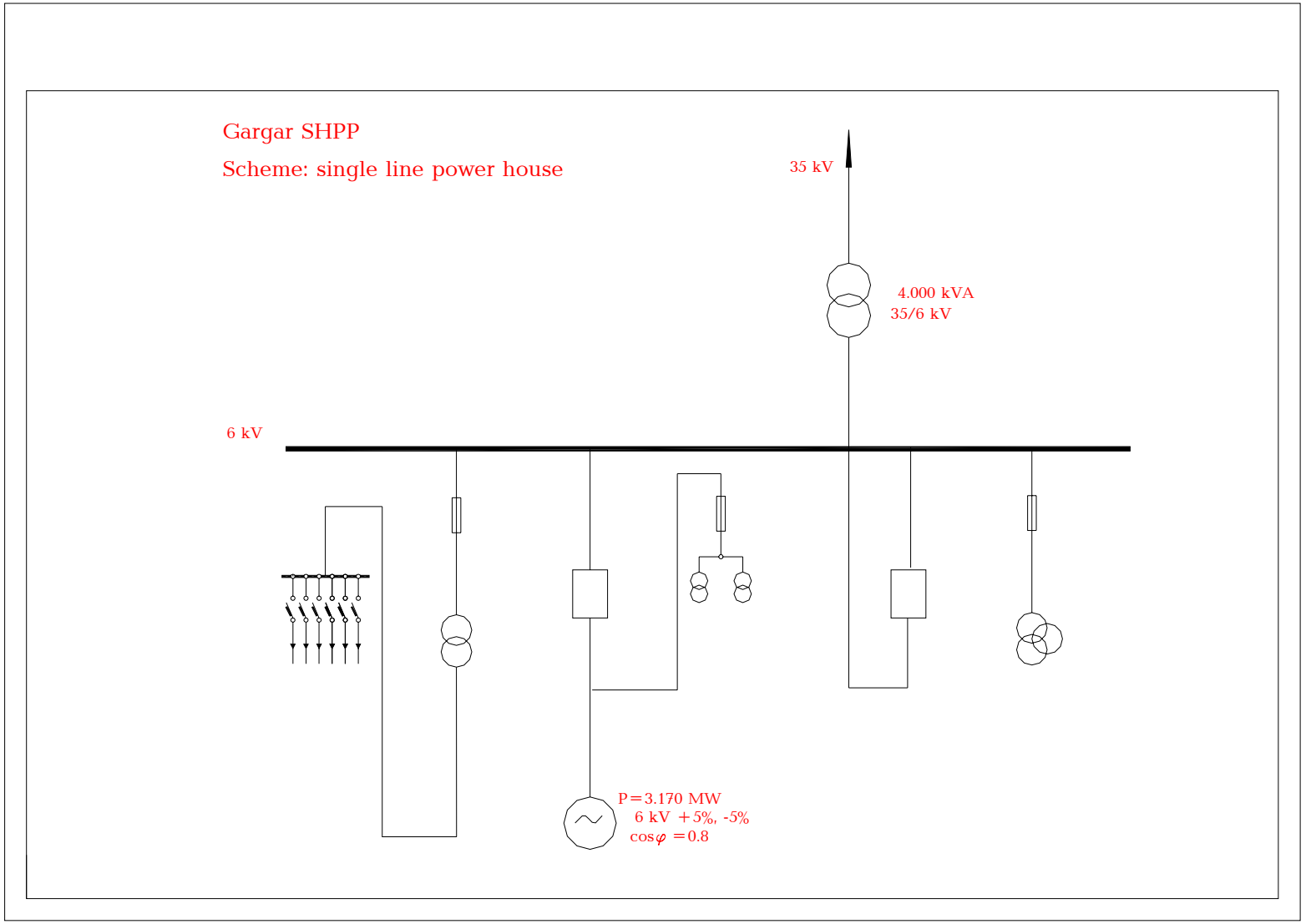

Figure: Single Line Diagram

Grid Connection

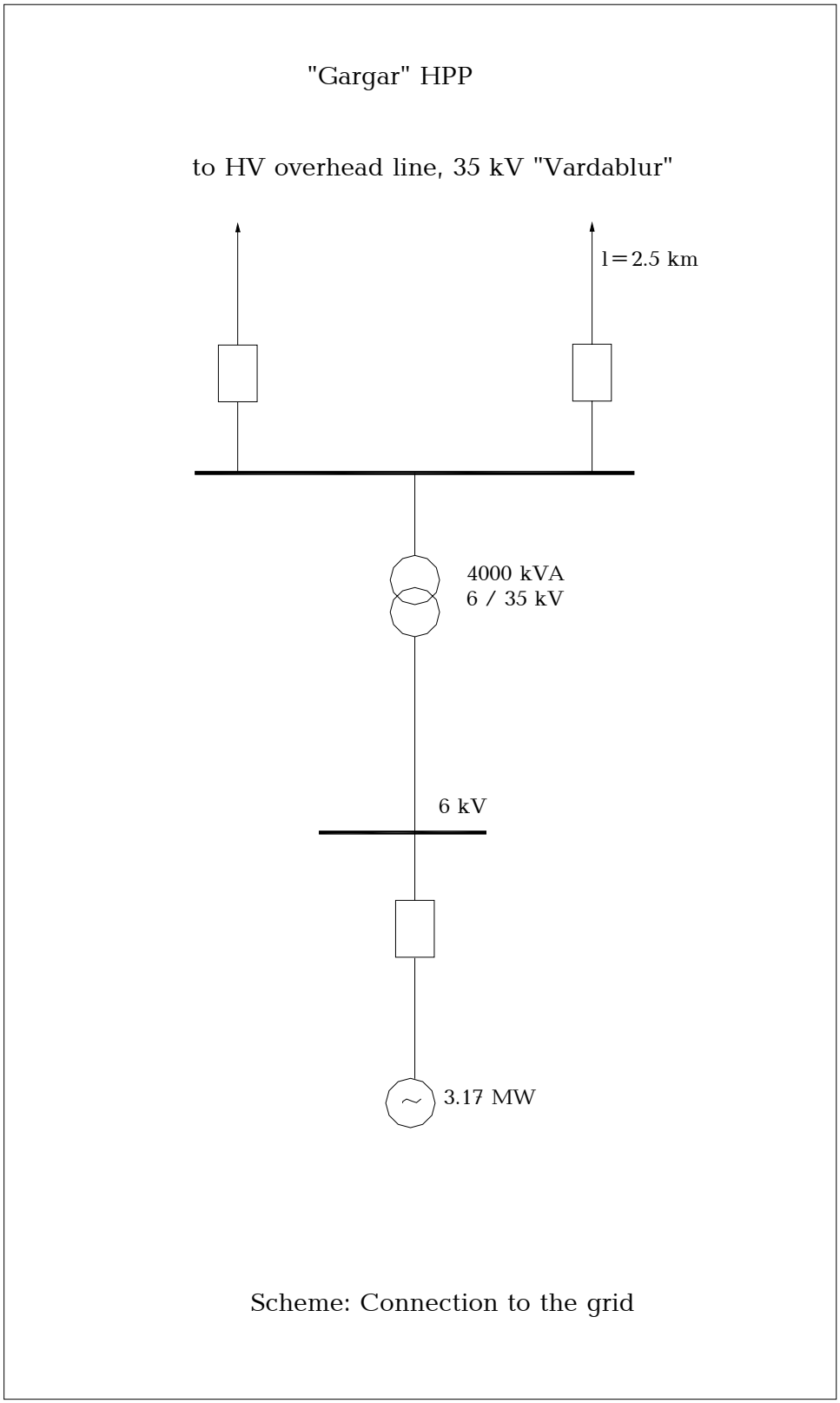

Figure: Transmission Line Scheme

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Quantities and Costs

Table of Content

Detailed Cost Estimations

Detailed Cost Estimations

Table: Detailed Cost Estimation (Local Prices)

Local Prices		UNIT	UNIT PRICE	QUANTITY	TOTAL
ITEM	DESCRIPTION	[unit]	[US$/unit]	[unit]	[US$]
1	**Tyrolean Weir**				
1.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	0.50	925	463
	Open cut excavation and transport of soil (Class B)	m^3	3.50	900	3150
	Open cut excavation and transport of rock (Class C)	m^3	8.80	900	7920
	Underlying sand layer	m^3	10.60	53	559
	Rip-rap	m^3	15	812	12173
1.2	**Concrete**				
	Concrete, B15	m^3	60.00	714	42841
	Formwork, highly accurate with smooth surfaces	m^2	10.00	365	3650
1.3	**Reinforcement**				
	Reinforcing Steel	t	692.00	29	19764
1.4	**Hydraulic Steel Structures**				
	Gate 1.5x1.5	kg.	3.50	1667	5835
	Trash Rack s=14mm b=6mm	m^2	80.00	17	1320
1.5	Bore-pile wall	m	240.00	140	33540
1.6	Apron from silty-clay	m^3	10	106	1064
2	**Water diversion during construction**				
2.1	**Earth Works**				
	Open cut excavation of soil (Class B)	m^3	2.75	900	2475
	Open cut excavation of rock (Class C)	m^3	8.05	2100	16905
	Soil Transportation 3 km	m^3	0.75	1625	1219
	Backfill	m^3	2.00	1375	2750
2.2	Coffer-dam	m^3	3.40	69	236
2.3	Coffer-dam dismantling	m^3	1.10	69	76
3	**Fishpass**				
3.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	0.50	38	19
	Open cut excavation and transport of soil (Class B)	m^3	3.50	78	273
	Open cut excavation and transport of rock (Class C)	m^3	8.80	182	1602
	Underlying sand layer	m^3	10.60	5	54
	Backfill	m^3	2.00	59	119
	Rip-rap	m^3	15	6	96
3.2	Apron from silty- clay	m^3	10	10	104
3.3	**Concrete**				
	Concrete, B15	m^3	60.00	37	2192
	Formwork, highly accurate with smooth surfaces	m^2	10.00	240	2396
3.4	**Reinforcement**				
	Reinforcing Steel	t	692.00	3	1769
3.5	**Hydraulic Steel Structures**				
	2 x Stoplogs 1.2x1.0, H=3m	kg.	3.50	706	2470
4	**Gravel Trap**				
4.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	0.50	54	27
	Open cut excavation and transport of soil (Class B)	m^3	3.50	120	420
	Open cut excavation and transport of rock (Class C)	m^3	8.80	180	1584
	Underlying sand layer	m^3	10.60	9	91
4.2	Apron from silty- clay	m^3	10	10	104
4.3	**Concrete**				
	Concrete, B15	m^3	60.00	171	10278
	Formwork, highly accurate with smooth surfaces	m^2	10.00	176	1760
4.4	**Reinforcement**				
	Reinforcing Steel	t	692.00	12	8298
4.5	**Hydraulic Steel Structures**				
	4 x Gate 1.5x1.5m, H=5m	kg.	3.50	6668	23338

Local Prices		UNIT	UNIT PRICE	QUANTITY	TOTAL
ITEM	DESCRIPTION	[unit]	[US$/unit]	[unit]	[US$]
5	**Sandtrap**				
5.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	0.50	520	260
	Open cut excavation and transport of soil (Class B)	m^3	3.50	735	2573
	Open cut excavation and transport of rock (Class C)	m^3	8.80	1715	15092
	Underlying sand layer	m^3	10.60	51	537
	Backfill	m^3	2.00	385	770
5.2	Apron from silty-clay	m^3	10	106	1064
5.3	**Concrete**				
	Concrete, B15	m^3	60.00	330	19800
	Formwork, highly accurate with smooth surfaces	m^2	10.00	2080	20800
5.4	**Reinforcement**				
	Reinforcing Steel	t	692.00	20	13702
6	**Sandtrap Flushing Channel**				
6.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	0.50	250	125
	Open cut excavation and transport of soil (Class B)	m^3	3.50	133	466
	Open cut excavation and transport of rock (Class C)	m^3	8.80	533	4686
	Underlying sand layer	m^3	10.60	4	44
	Backfill	m^3	2.00	250	499
	Rip-rap	m^3	15	38	563
6.2	**Concrete**				
	Concrete, B15	m^3	60.00	12	729
	Formwork, highly accurate with smooth surfaces	m^2	10.00	228	2275
6.3	**Reinforcement**				
	Reinforcing Steel	t	692.00	1	589
6.4	**Hydraulic Steel Structures**				
	2x1 Gate 2.0x1.5 b=2m, h=1.5m, H=6	kg.	3.50	2784	9743
7	**Penstock Intake**				
7.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	0.50	26	13
	Open cut excavation and transport of soil (Class B)	m^3	3.50	165	578
	Open cut excavation and transport of rock (Class C)	m^3	8.80	385	3388
	Underlying sand layer	m^3	10.60	4	41
7.2	**Concrete**				
	Concrete, B15	m^3	60.00	166	9948
	Formwork, highly accurate with smooth surfaces	m^2	10.00	134	1344
7.3	**Reinforcement**				
	Reinforcing Steel	t	692.00	8	5737
7.4	**Hydraulic Steel Structures**				
	2x1 Gate 2.0x1.0 H=4	kg.	3.50	2229	7802
	Gate 1.5x1.5m, H=5m	kg.	3.50	1667	5835
	Trash Rack s=20mm b=10mm	m^2	80.00	2	180
8	**Penstock**	L=	2160		
8.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	0.50	21600	10800
	Open cut excavation and transport of soil (Class B)	m^3	3.50	19650	68775
	Open cut excavation and transport of rock (Class C)	m^3	8.80	45850	403480
	Trench excavation	m^3	8.80	7000	61600
	Underlying sand layer	m^3	10.60	907	9616
	Backfill	m^3	0.10	10785	1079
8.2	**Concrete**				
	Reinforced concrete, B15 (bearings for river crossing)	m^3	60.00	144	8640
	Formwork, rough	m^2	10.00	72	720
8.3	**Reinforcement**				
	Reinforcing Steel	t	692.00	3	1993
8.4	**Hydraulic Steel Structures**				
	Penstock	t	1220.00	471	574364
	Anticorrosice insulation with bitumen	m^2	5.7	6922	39453

Local Prices		UNIT	UNIT PRICE	QUANTITY	TOTAL
ITEM	DESCRIPTION	[unit]	[US$/unit]	[unit]	[US$]
9	**Powerhouse**				
9.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	0.50	1705	853
	Open cut excavation and transport of soil (Class B)	m^3	3.50	1145	4008
	Open cut excavation and transport of rock (Class C)	m^3	8.80	1010	8888
	Underlying sand layer	m^3	10.60	34	358
9.2	**Concrete**				
	Substructure - Structural concrete with reinfoecement, B35	m^3	101.00	405	40905
	Superstructure - Structural concrete with reinforcement, B35	m^3	112.60	330	37158
	Formwork, rough	m^2	10.00	660	6600
9.3	**Switchyard**	m^3			
	Concrete Works	m^3	85.00	30	2550
9.4	**Hydraulic Steel Structures**				
	1 Panel - b=2.0m, h=1.5m, H=2	kg.	3.50	790	2764
9.5	**Mobile Cranes- Powerhouse**				
	Crane for D/S Stop Log W=1 t	ls	2500.00	1	2500
	Crane in Machine Hall W=30t	ls	40000	1	40000
9.6	**Turbine-Generator Set**				
	Equipment and Auxilliary Equipment	kW	400.0	3170.00	1268000
9.7	**Electrical Equipment**				
	Main Transformator 6/35 kV, 4.0 MVA	l.s.	35000	1	35000
	Switchpanel 35kV	l.s.	12500	2	25000
	Switchpanel 6kV	l.s.	4000	2	8000
	Station Service Equipment (Own Requir., DC, etc.)	l.s.	28000	1	28000
	Powerhaus Installation	l.s.	6000	1	28000
	Miscellaneous Items (Fire Fighting System, Earthing System, HVAC)	l.s.	10000	1	6000
10	**Transmission Line**				
10.1	**Transmission Line**	km	25000.00	2.5	62500
11	**Tailrace Canal**				
11.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	0.50	200	100
	Open cut excavation and transport of soil (Class B)	m^3	3.50	200	700
	Open cut excavation and transport of rock (Class C)	m^3	8.80	50	440
	Underlying sand layer	m^3	10.60	27	286
	Backfill	m^3	0.10	100	10
	Rip-rap	m^3	15	25	375
11.2	**Concrete**				
	Concrete, B15	m^3	60.00	99	5940
	Formwork, highly accurate with smooth surfaces	m^2	20.00	450	9000
11.3	**Reinforcement**				
	Reinforcing Steel	t	700.00	6	4158
12	**Environmental Mitigation Costs**				
	Environmental Mitigation Costs	l.s.	133400	1	133400
13	**Preliminary and General**				
13.1	**Preliminary and General**	l.s.	19492.39	1	19492
13.2	**Access Roads**	m	60.00	1000	60000
	Total				**3363615**

Table: Detailed Cost Estimation (International Prices)

Local Prices ITEM	DESCRIPTION	UNIT [unit]	UNIT PRICE [US$/unit]	QUANTITY [unit]	TOTAL [US$]
1	**Tyrolean Weir**				
1.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	1.00	925	925
	Open cut excavation and transport of soil (Class B)	m^3	5.00	900	4500
	Open cut excavation and transport of rock (Class C)	m^3	20.00	900	18000
	Underlying sand layer	m^3	15.00	53	791
	Rip-rap	m^3	20	812	16231
1.2	**Concrete**				
	Concrete, B15	m^3	100.00	714	71401
	Formwork, highly accurate with smooth surfaces	m^2	20.00	365	7300
1.3	**Reinforcement**				
	Reinforcing Steel	t	700.00	29	19992
1.4	**Hydraulic Steel Structures**				
	Gate 1.5x1.5	kg.	5.00	1667	8335
	Trash Rack s=14mm b=6mm	m^2	150.00	17	2475
1.5	Bore-pile wall	m	360.00	140	50310
1.6	Apron from silty-clay	m^3	20	106	2128
2	**Water diversion during construction**				
2.1	**Earth Works**				
	Open cut excavation of soil (Class B)	m^3	5.00	900	4500
	Open cut excavation of rock (Class C)	m^3	20.00	2100	42000
	Soil Transportation 3 km	m^3	2.00	1625	3250
	Backfill	m^3	5.00	1375	6875
2.2	Coffer-dam	m^3	20.00	69	1387
2.3	Coffer-dam dismantling	m^3	4.00	69	277
3	**Fishpass**				
3.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	1.00	38	38
	Open cut excavation and transport of soil (Class B)	m^3	5.00	78	390
	Open cut excavation and transport of rock (Class C)	m^3	20.00	182	3640
	Underlying sand layer	m^3	15.00	5	77
	Backfill	m^3	5.00	59	297
	Rip-rap	m^3	20	6	128
3.2	Apron from silty- clay	m^3	20	10	207
3.3	**Concrete**				
	Concrete, B15	m^3	100.00	37	3653
	Formwork, highly accurate with smooth surfaces	m^2	20.00	240	4793
3.4	**Reinforcement**				
	Reinforcing Steel	t	700.00	3	1790
3.5	**Hydraulic Steel Structures**				
	2 x Stoplogs 1.2x1.0, H=3m	kg.	8.00	706	5647
4	**Gravel Trap**				
4.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	1.00	54	54
	Open cut excavation and transport of soil (Class B)	m^3	5.00	120	600
	Open cut excavation and transport of rock (Class C)	m^3	20.00	180	3600
	Underlying sand layer	m^3	15.00	9	128
4.2	Apron from silty- clay	m^3	10	10	104
4.3	**Concrete**				
	Concrete, B15	m^3	100.00	171	17130
	Formwork, highly accurate with smooth surfaces	m^2	20.00	176	3520
4.4	**Reinforcement**				
	Reinforcing Steel	t	700.00	12	8394
4.5	**Hydraulic Steel Structures**				
	4 x Gate 1.5x1.5m, H=5m	kg.	8.00	6668	53344

Local Prices		UNIT	UNIT PRICE	QUANTITY	TOTAL
ITEM	DESCRIPTION	[unit]	[US$/unit]	[unit]	[US$]
5	**Sandtrap**				
5.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	1.00	520	520
	Open cut excavation and transport of soil (Class B)	m^3	5.00	735	3675
	Open cut excavation and transport of rock (Class C)	m^3	20.00	1715	34300
	Underlying sand layer	m^3	15.00	51	761
	Backfill	m^3	5.00	385	1925
5.2	Apron from silty-clay	m^3	20	106	2128
5.3	**Concrete**				
	Concrete, B15	m^3	100.00	330	33000
	Formwork, highly accurate with smooth surfaces	m^2	20.00	2080	41600
5.4	**Reinforcement**				
	Reinforcing Steel	t	700.00	20	13860
6	**Sandtrap Flushing Channel**				
6.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	1.00	250	250
	Open cut excavation and transport of soil (Class B)	m^3	5.00	133	666
	Open cut excavation and transport of rock (Class C)	m^3	20.00	533	10650
	Underlying sand layer	m^3	15.00	4	62
	Backfill	m^3	5.00	250	1248
	Rip-rap	m^3	20	38	750
6.2	**Concrete**				
	Concrete, B15	m^3	100.00	12	1215
	Formwork, highly accurate with smooth surfaces	m^2	20.00	228	4550
6.3	**Reinforcement**				
	Reinforcing Steel	t	700.00	1	595
6.4	**Hydraulic Steel Structures**				
	2x1 Gate 2.0x1.5 b=2m, h=1.5m, H=6	kg.	8.00	2784	22271
7	**Penstock Intake**				
7.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	1.00	26	26
	Open cut excavation and transport of soil (Class B)	m^3	5.00	165	825
	Open cut excavation and transport of rock (Class C)	m^3	20.00	385	7700
	Underlying sand layer	m^3	15.00	4	59
7.2	**Concrete**				
	Concrete, B15	m^3	100.00	166	16580
	Formwork, highly accurate with smooth surfaces	m^2	20.00	134	2688
7.3	**Reinforcement**				
	Reinforcing Steel	t	700.00	8	5803
7.4	**Hydraulic Steel Structures**				
	2x1 Gate 2.0x1.0 H=4	kg.	5.00	2229	11146
	Gate 1.5x1.5m, H=5m	kg.	5.00	1667	8335
	Trash Rack s=20mm b=10mm	m^2	150.00	2	338
8	**Penstock**	L=	2160		
8.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	1.00	21600	21600
	Open cut excavation and transport of soil (Class B)	m^3	5.00	19650	98250
	Open cut excavation and transport of rock (Class C)	m^3	20.00	45850	917000
	Trench excavation	m^3	20.00	7000	140000
	Underlying sand layer	m^3	15.00	907	13608
	Backfill	m^3	5.00	10785	53925
8.2	**Concrete**				
	Reinforced concrete, B15 (bearings for river crossing)	m^3	100.00	144	14400
	Formwork, rough	m^2	20.00	72	1440
8.3	**Reinforcement**				
	Reinforcing Steel	t	700.00	3	2016
8.4	**Hydraulic Steel Structures**				
	Penstock	t	2500.00	471	1176975

Local Prices		UNIT	UNIT PRICE	QUANTITY	TOTAL
ITEM	DESCRIPTION	[unit]	[US$/unit]	[unit]	[US$]
9	**Powerhouse**				
9.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	1.00	1705	1705
	Open cut excavation and transport of soil (Class B)	m^3	5.00	1145	5725
	Open cut excavation and transport of rock (Class C)	m^3	20.00	1010	20200
	Underlying sand layer	m^3	15.00	34	506
9.2	**Concrete**				
	Substructure - Structural concrete with reinfoecement, B35	m^3	120.00	405	48600
	Superstructure - Structural concrete with reinforcement, B35	m^3	140.00	330	46200
	Formwork, rough	m^2	20.00	660	13200
9.3	**Switchyard**	m^3			
	Concrete Works	m^3	100.00	30	3000
9.4	**Hydraulic Steel Structures**				
	1 Panel - b=2.0m, h=1.5m, H=2	kg.	8.00	790	6317
9.5	**Mobile Cranes- Powerhouse**				
	Crane for D/S Stop Log W=1 t	ls	2500.00	1	2500
	Crane in Machine Hall W=30t	ls	40000	1	40000
9.6	**Turbine-Generator Set**				
	Equipment and Auxilliary Equipment	kW	400.0	3170.00	1268000
9.7	**Electrical Equipment**				
	Main Transformator 6/35 kV, 4.0 MVA	l.s.	88000	1	88000
	Switchpanel 35kV	l.s.	54000	2	108000
	Switchpanel 6kV	l.s.	36000	2	72000
	Station Service Equipment (Own Requir., DC, etc.)	l.s.	70000	1	70000
	Powerhaus Installation	l.s.	11000	1	70000
	Miscellaneous Items (Fire Fighting System, Earthing System, HVAC)	l.s.	25000	1	11000
10	**Transmission Line**				
10.1	**Transmission Line**	km	54000	2.5	135000
11	**Tailrace Canal**				
11.1	**Earth Works**				
	Preparation of construction area by clearing, grubbing and stripping	m^2	1.00	200	200
	Open cut excavation and transport of soil (Class B)	m^3	5.00	200	1000
	Open cut excavation and transport of rock (Class C)	m^3	20.00	50	1000
	Underlying sand layer	m^3	15.00	27	405
	Backfill	m^3	5.00	100	500
	Rip-rap	m^3	20	25	500
11.2	**Concrete**				
	Concrete, B15	m^3	100.00	99	9900
	Formwork, highly accurate with smooth surfaces	m^2	20.00	450	9000
11.3	**Reinforcement**				
	Reinforcing Steel	t	700.00	6	4158
12	**Environmental Mitigation Costs**				
	Environmental Mitigation Costs	l.s.	133400	1	133400
13	**Preliminary and General**				
13.1	**Preliminary and General**	l.s.	38237.63	1	38238
13.2	**Access Roads**	m	60.00	1000	60000
	Total				**5303201**

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Project Implementation

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Project Implementation Schedule

ID	Task Name
1	**Preliminary and General**
2	Arrangement of temporary access roads
3	Clearing and grubbing the erection site from bushes and
4	Blasting and excavation of rocks
5	Excavation of soil
6	Leveling of the surface
7	**River diversion during construction**
8	Blasting and excavation of rocks
9	Excavation of soil
10	Soil transportation for 3 km
11	Backfill
12	Construction and dismantling of cofferdam
13	**Water intake, sandtrap and flusher**
14	Clearing and grubbing the erection site from bushes and
15	Blasting and excavation of rocks
16	Excavation of soil
17	Sand bedding layer
18	Construction of silty-clay apron with compaction
19	Arrangement and dismantling of formwork
20	Reinforced concrete
21	Installation of gates
22	Rip-rap
23	Backfill
24	**Fishpass, weir with stilling basin and gravel trap**
25	Clearing and grubbing the erection site from bushes and
26	Blasting and excavation of rocks
27	Excavation of soil
28	Sand bedding layer
29	Construction of silty-clay apron with compaction
30	Arrangement and dismantling of formwork
31	Reinforced concrete
32	Installation of gates
33	Rip-rap
34	Backfill
35	Bore-pile wall
36	**Penstock**
37	Clearing and grubbing the erection site from bushes and
38	Blasting and excavation of rocks
39	Excavation of soil
40	Trench bedding in soil
41	Sand bedding layer
42	Leveling of the access road surface with a width of 6m
43	Lying of penstock D 1220x10mm
44	2- layer anticorrosion coating
45	Backfill
46	Arrangement and dismantling of formwork
47	Reinforced concrete
48	**Powerhouse**
49	Clearing and grubbing the erection site from bushes and
50	Blasting and excavation of rocks
51	Excavation of soil
52	Sand bedding layer
53	Arrangement and dismantling of formwork
54	Reinforced concrete
55	Backfill
56	Rip-rap
57	Assembly of mechanical equipment
58	Assembly of hydromechanical equipment
59	Assembly of electrical equipment and swith yard
60	**Testing and Commissioning**
61	Testing
62	Commissioning

Project: Gargar_workprogramme
Date: 05/10/12 15:34

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

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Financial Analysis

Table of Content

Cash Flow Calculations

Financial Indicators (Local Prices)

Parameters and Assumptions:

Installed capacity	MW	3.2
Energy generation	MWh	12,190
Useful output (1% station use, 1% transm. losses)	MWh	11,947
Investment Cost (incl. price contingencies)	TUS$	3,884
Annual O&M Cost (1% of direct cost)	TUS$	35
Tariff	c/kWh	4.5

Results:

Discount Rate	8%	10%	12%	14%	16%
DPC (c/kWh)	3.3	3.9	4.6	5.2	6.0
NPV (TUS$)	1,107	415	-33	-325	-513
B/C Ratio	1.37	1.15	0.99	0.86	0.76
IRR	11.8	Simple Payback Period		7.7	years

Cash Flow for Calculation of Financial Indicators:

Year	Gene-ration	Invest-ment	O&M Cost	Total Cost	Rev-enue	Net Cash Flow	Cum. NCF
	MWh	TUS$	TUS$	TUS$	TUS$	TUS$	TUS$
-2		1,863		1,863		-1,863	-1,863
-1		2,021		2,021		-2,021	-3,884
1	11,947		35	35	538	503	-3,382
2	11,947		35	35	538	503	-2,879
3	11,947		35	35	538	503	-2,376
4	11,947		35	35	538	503	-1,874
5	11,947		35	35	538	503	-1,371
6	11,947		35	35	538	503	-868
7	11,947		35	35	538	503	-365
8	11,947		35	35	538	503	137
9	11,947		35	35	538	503	640
10	11,947		35	35	538	503	1,143
11	11,947		35	35	538	503	1,646
12	11,947		35	35	538	503	2,148
13	11,947		35	35	538	503	2,651
14	11,947		35	35	538	503	3,154
15	11,947		35	35	538	503	3,657
16	11,947		35	35	538	503	4,159
17	11,947		35	35	538	503	4,662
18	11,947		35	35	538	503	5,165
19	11,947		35	35	538	503	5,667
20	11,947		35	35	538	503	6,170
21	11,947		35	35	538	503	6,673
22	11,947		35	35	538	503	7,176
23	11,947		35	35	538	503	7,678
24	11,947		35	35	538	503	8,181
25	11,947		35	35	538	503	8,684
26	11,947		35	35	538	503	9,187
27	11,947		35	35	538	503	9,689
28	11,947		35	35	538	503	10,192
29	11,947		35	35	538	503	10,695
30	11,947		35	35	538	503	11,197
Total	358,423	3,884	1,047	4,932	16,129	11,197	
NPV @ 10%	69,933	2,528	204	2,732	3,147	415	
NPV @ 12%	54,608	2,331	160	2,491	2,457	-33	
NPV @ 14%	43,452	2,153	127	2,280	1,955	-325	

Financial Indicators (International Prices)

Parameters and Assumptions:

Installed capacity	MW	3.2
Energy generation	MWh	12,190
Useful output (1% station use, 1% transm. losses)	MWh	11,947
Investment Cost incl. price contingencies)	TUS$	5,962
Annual O&M Cost (1% of direct cost)	TUS$	54
Tariff	c/kWh	4.5

Results:

Discount Rate	8%	10%	12%	14%	16%
DPC (c/kWh)	5.1	6.0	7.0	8.1	9.2
NPV (TUS$)	-516	-1,057	-1,376	-1,554	-1,643
B/C Ratio	0.89	0.7	0.6	0.6	0.5
IRR	6.7%	Simple Payback Period		12.3	years

Cash Flow for Calculation of Financial Indicators (International Prices)

Year	Gene-ration	Invest-ment	O&M Cost	Total Cost	Rev-enue	Net Cash Flow	Cum. NCF
	MWh	TUS$	TUS$	TUS$	TUS$	TUS$	TUS$
-2		2,971		2,971		-2,971	-2,971
-1		2,991		2,991		-2,991	-5,962
1	11,947		54	54	538	483	-5,478
2	11,947		54	54	538	483	-4,995
3	11,947		54	54	538	483	-4,512
4	11,947		54	54	538	483	-4,028
5	11,947		54	54	538	483	-3,545
6	11,947		54	54	538	483	-3,062
7	11,947		54	54	538	483	-2,578
8	11,947		54	54	538	483	-2,095
9	11,947		54	54	538	483	-1,612
10	11,947		54	54	538	483	-1,128
11	11,947		54	54	538	483	-645
12	11,947		54	54	538	483	-162
13	11,947		54	54	538	483	322
14	11,947		54	54	538	483	805
15	11,947		54	54	538	483	1,288
16	11,947		54	54	538	483	1,772
17	11,947		54	54	538	483	2,255
18	11,947		54	54	538	483	2,738
19	11,947		54	54	538	483	3,222
20	11,947		54	54	538	483	3,705
21	11,947		54	54	538	483	4,188
22	11,947		54	54	538	483	4,672
23	11,947		54	54	538	483	5,155
24	11,947		54	54	538	483	5,638
25	11,947		54	54	538	483	6,122
26	11,947		54	54	538	483	6,605
27	11,947		54	54	538	483	7,088
28	11,947		54	54	538	483	7,572
29	11,947		54	54	538	483	8,055
30	11,947		54	54	538	483	8,538
Total	358,423	5,962	1,629	7,591	16,129	8,538	
NPV @ 10%	69,933	3,886	318	4,204	3,147	-1,057	
NPV @ 12%	54,608	3,585	248	3,833	2,457	-1,376	
NPV @ 14%	43,452	3,312	197	3,510	1,955	-1,554	

Financial Statements

Financial Statements (Local Prices) at Tariff 4.5 c/kWh

Production and Tariff

	Year	1 2007	2 2009	3 2010	4 2011	5 2012	6 2013	7 2014	8 2015	9 2016	10 2017	11 2018	12 2019	13 2020	14 2021	15 2022	16 2023	17 2024	18 2025	19 2026	20 2027	21 2028	22 2029	23 2030	24 2031	25 2032	26 2033	27 2034	28 2035	29 2036	30 2037
Project Output																															
Net Energy Output	MWh	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947	11,947
Net Capacity	MW	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Tariff and Revenues																															
Tariff	cents/kWh	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Total Revenue	US$ '000	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538

Cash Flow

All values in US$ '000	Year	1 2007	2 2009	3 2010	4 2011	5 2012	6 2013	7 2014	8 2015	9 2016	10 2017	11 2018	12 2019	13 2020	14 2021	15 2022	16 2023	17 2024	18 2025	19 2026	20 2027	21 2028	22 2029	23 2030	24 2031	25 2032	26 2033	27 2034	28 2035	29 2036	30 2037
Revenues		538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538
Operating Expenses		35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Operating Income (EBIDTA)		503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503
Change in Working Capital		48																													-48
Other Sources of Cash: Residual Value																															0
Cash Flow Available for Debt Service		455	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	503	550
Total Debt Service		540	527	506	484	460	433	404	372	337	304													-5	-11	-18	-25	-32	-39	-46	-53
Pre-Tax Cash-Flow		-85	-24	-4	19	43	69	99	131	166	199	503	503	503	503	503	503	503	503	503	503	503	503	507	514	521	528	535	542	549	604
Corporate Tax		23	26	30	34	39	44	50	57	64	70	73	73	73	73	73	73	73	73	73	73	73	73	74	75	77	78	79	81	82	83
After-Tax Cash-Flow		-108	-50	-33	-16	4	25	48	74	102	128	430	430	430	430	430	430	430	430	430	430	430	430	434	439	445	450	456	461	467	520
Cash Available for Distributions		-108	-158	-191	-207	-203	-178	-129	-55	47	128	430	430	430	430	430	430	430	430	430	430	430	430	524	669	813	957	1,101	1,245	1,389	1,581
Dividends Paid										47	128	430	430	430	430	430	430	430	430	430	430	430	339	295	300	306	312	317	323	328	334
Return of Capital																															1,247
Net Cash Flow for the Period		-108	-50	-33	-16	4	25	48	74	55													91	139	139	139	139	139	139	139	-1,061
Cash Balance brought forward			-108	-158	-191	-207	-203	-178	-129	-55														91	229	368	507	645	784	922	1,061
Cash Balance carried forward		-108	-158	-191	-207	-203	-178	-129	-55														91	229	368	507	645	784	922	1,061	0

	ROE	Payback yrs																														
Pre-Tax Investor's Cash Flow	12.5%	11.3	-1,247	-85	-24	-4	19	43	69	99	131	166	199	503	503	503	503	503	503	503	503	503	503	503	507	514	521	528	535	542	549	604
Post-Tax Cash Flow distributed	10.7%	12.5	-1,247									47	128	430	430	430	430	430	430	430	430	430	430	430	339	295	300	306	312	317	323	328	1,581

Income Statement

All values in US$ '000	Year	1 2007	2 2009	3 2010	4 2011	5 2012	6 2013	7 2014	8 2015	9 2016	10 2017	11 2018	12 2019	13 2020	14 2021	15 2022	16 2023	17 2024	18 2025	19 2026	20 2027	21 2028	22 2029	23 2030	24 2031	25 2032	26 2033	27 2034	28 2035	29 2036	30 2037
Total Operating Revenues		538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538	538
Operating Expenses		35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Depreciation		139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139	139
Operating Costs		173	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173
Operating Income (EBIDTA)		364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364	364
Interest Expense		249	236	215	193	169	142	113	81	46	13													-5	-11	-18	-25	-32	-39	-46	-53
Profit before Tax		115	129	149	171	195	222	251	283	318	351	364	364	364	364	364	364	364	364	364	364	364	364	369	376	383	389	396	403	410	417
Corporate Tax		23	26	30	34	39	44	50	57	64	70	73	73	73	73	73	73	73	73	73	73	73	73	74	75	77	78	79	81	82	83
Profit for Year		92	103	119	137	156	178	201	227	255	281	291	291	291	291	291	291	291	291	291	291	291	291	295	300	306	312	317	323	328	334
Profit Available for Distribution		92	195	314	451	607	785	986	1,212	1,467	1,701	1,864	1,725	1,586	1,448	1,309	1,171	1,032	893	755	616	478	339	295	300	306	312	317	323	328	334
Dividend Paid										47	128	430	430	430	430	430	430	430	430	430	430	430	339	295	300	306	312	317	323	328	334

Balance Sheet

All values in US$ '000	Year	1 2007	2 2009	3 2010	4 2011	5 2012	6 2013	7 2014	8 2015	9 2016	10 2017	11 2018	12 2019	13 2020	14 2021	15 2022	16 2023	17 2024	18 2025	19 2026	20 2027	21 2028	22 2029	23 2030	24 2031	25 2032	26 2033	27 2034	28 2035	29 2036	30 2037
Assets																															
Gross Fixed Assets		4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158	4,158
Less Accumulated Depreciation		139	277	416	554	693	832	970	1,109	1,247	1,386	1,524	1,663	1,802	1,940	2,079	2,217	2,356	2,495	2,633	2,772	2,910	3,049	3,188	3,326	3,465	3,603	3,742	3,881	4,019	4,158
Less Sale of Assets																															0
Net Book Value		4,019	3,881	3,742	3,603	3,465	3,326	3,188	3,049	2,910	2,772	2,633	2,495	2,356	2,217	2,079	1,940	1,802	1,663	1,525	1,386	1,247	1,109	970	832	693	554	416	277	139	
Work in Progress																															
Fixed Assets		4,019	3,881	3,742	3,603	3,465	3,326	3,188	3,049	2,910	2,772	2,633	2,495	2,356	2,217	2,079	1,940	1,802	1,663	1,525	1,386	1,247	1,109	970	832	693	554	416	277	139	
Cash																							91	229	368	507	645	784	922	1,061	
Accounts Receivable		45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	
Inventory		6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	
Reserve Account																															
Current Assets		51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51	141	280	419	557	696	834	973	1,112	
Total Assets		4,070	3,931	3,793	3,654	3,515	3,377	3,238	3,100	2,961	2,822	2,684	2,545	2,407	2,268	2,129	1,991	1,852	1,714	1,575	1,437	1,298	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250	
Equity																															
Equity		1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	0
Retained Earnings		92	195	314	451	607	785	986	1,212	1,420	1,572	1,434	1,295	1,156	1,018	879	741	602	463	325	186	48									
Total Equity		1,340	1,442	1,561	1,698	1,854	2,032	2,233	2,459	2,667	2,820	2,681	2,542	2,404	2,265	2,127	1,988	1,849	1,711	1,572	1,434	1,295	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	0
Bank Overdraft		108	158	191	207	203	178	129	55																						0
Accounts Payable		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	
Current Liabilities		111	160	194	210	206	181	132	58	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0
Long Term Liabilities		2,619	2,328	2,037	1,746	1,455	1,164	873	582	291																					
Total Liabilities		4,070	3,931	3,793	3,654	3,515	3,377	3,238	3,100	2,961	2,822	2,684	2,545	2,407	2,268	2,129	1,991	1,852	1,714	1,575	1,437	1,298	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250	0
Check																															0.00

Loan Schedule

All values in US$ '000	Year	1 2007	2 2009	3 2010	4 2011	5 2012	6 2013	7 2014	8 2015	9 2016	10 2017	11 2018	12 2019	13 2020	14 2021	15 2022	16 2023	17 2024	18 2025	19 2026	20 2027	21 2028	22 2029	23 2030	24 2031	25 2032	26 2033	27 2034	28 2035	29 2036	30 2037
Disbursement	2,910																														
Loan Repayment		291	291	291	291	291	291	291	291	291	291																				
Loan Balance (end of period)		2,619	2,328	2,037	1,746	1,455	1,164	873	582	291																					
Interest Payments		249	223	196	170	144	118	92	65	39	13																				
Interest on Overdraft/Interest Income			13	19	23	25	24	21	16	7																					
Debt Service		540	527	506	484	460	433	404	372	337	304																				
Operating Income		503	503	503	503	503	503	503	503	503	503																				
Debt Service Coverage Ratio		0.93	0.95	0.99	1.04	1.09	1.16	1.24	1.35	1.49	1.65																				

Min	0.93
Max	1.65
Average	1.19